SAP Worksheet #1—Title and Approval Page

Draft

Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Radiological Data Evaluation and Confirmation Survey

Hunters Point Naval Shipyard San Francisco, California

Contract Task Order FZ12
DCN: CH2M-9000-FZ12-0004

June 2017

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Base Realignment and Closure
Program Management Office West

Under the

NAVFAC CLEAN 9000 Program
Contract N62470-16-D-9000

Prepared by

San Diego, California

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SAP Worksheet #1—Title and Approval Page (continued)

Review Signature:

June 23, 2017

Anita Dodson — Date
CH2M HILL, Inc. Program Chemist

Approval Signature:

ARLAUSKAS.JOSEPH.1229257192

Digitally signed by ARLAUSKAS.JOSEPH.1229257192
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USN, cn=ARLAUSKAS.JOSEPH.1229257192
Date: 2017.06.14 13:28:09 -07'00'

Joseph Arlauskas — Date
Naval Facilities Engineering Command Southwest Quality Assurance Officer

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Executive Summary

This document presents the Tier I Sampling and Analysis Plan (SAP) for confirmation survey sampling at Hunters Point Naval Shipyard (HPNS), located in San Francisco, California. HPNS lies entirely within the corporate boundaries of the City and County of San Francisco, California, near the county's southern boundary with San Mateo County. HPNS is located on San Francisco Bay in the southeast corner of San Francisco. The site encompasses approximately 848 acres, including approximately 416 acres on land, at the point of a high, rocky, 2-mile-long peninsula projecting southeastward into San Francisco Bay (the Bay). HPNS is divided into seven parcels; Parcels A through E and Parcel G encompass onshore areas and Parcel F comprises offshore areas. In November 2004, Parcel A was transferred to the City and County of San Francisco. Radiologically impacted sites that will be addressed under this UFP SAP include, former radiologically impacted areas in Parcels B, C, D-2, E, G, and utility corridors, UC-1, UC-2, and UC-3.

Hazardous materials are present at HPNS because of previous shipyard operations. Investigation and cleanup of contamination at HPNS by the Navy has been underway since the 1980s. In 1989, the U.S. Environmental Protection Agency (USEPA) placed HPNS on the National Priorities List as a Superfund site pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act.

In addition to previous investigation and cleanup activities, the Navy has been evaluating and cleaning up sites specifically identified in the Historical Radiological Assessment of HPNS since its publication in 2004.

Approximately 90 percent of the work has been completed. The Navy works in conjunction with federal and state regulatory agencies to make decisions on the environmental conditions of the property to ensure public safety prior to transfer outside of the Navy's ownership.

In 2012, during review of systematic radiological soil sample analytical data the Navy Radiological Affairs Support Office found that the analytical data submitted did not correspond to soil samples taken from the same site. This led to suspicion that the soil samples were improperly collected. The contractor conducted an internal investigation to identify the source of the discrepancy and took corrective action. The results are presented in a report finalized in 2014 (TtEC, 2015).

Several agencies, including the Nuclear Regulatory Commission, were or are currently conducting investigations regarding the possible misrepresentation of data during radiological remediation activities at HPNS. As a result, USEPA and the Department of Toxic Substance Control (DTSC), the lead federal and state regulatory agencies overseeing HPNS cleanup work, have stated that they will not support the transfer of HPNS property to the City of San Francisco until they are more confident that remedial decisions made were based on factual data (USEPA and DTSC, 2016). Specifically, USEPA and DTSC directed in the letter that "the Navy will not propose any further transfers of Navy property at HPNS without results of these investigations and/or any other Navy action necessary to clarify the actual potential public exposure to radioactive material at and near the HPNS" (USEPA and DTSC, 2016).The purpose of this project is two-fold:

1. To perform a comprehensive assessment of a component (or subset) of the existing radiological data in order to determine its' validity to support decisions regarding transfer of property at HPNS; and,
2. To conduct confirmation survey sampling to confirm or corroborate data assessment findings and/or prior sampling results from previous radiological remediation activities. Soil confirmation samples will be collected from areas where questions or concerns remain regarding the possible misrepresentation of data during radiological remediation activities at HPNS. The soil confirmation sample data obtained will be used to determine whether additional action and/or samples are necessary to supplement prior sampling results.

Prior to conducting field activities, a data assessment will be conducted in two phases to evaluate radiological data and determine how to conduct confirmation sampling. The two phases consist of the following:

- Phase 1 is underway to develop a soil database with available data, conduct soil data evaluation to identify anomalies indicating potential data falsification while validating sources of usable data, and identify data gaps for Phase 2 evaluation.
- Phase 2 will be conducted as a detailed review to further evaluate anomalous data identified during Phase 1 and to design and conduct confirmation sampling.

Soil confirmation survey sampling will be conducted to confirm or corroborate data evaluation findings and/or prior sampling results from previous radiological remediation activities. Soil samples will be collected from areas where questions or concerns remain regarding the possible misrepresentation of data during radiological remediation activities at HPNS. Examples of areas of previous remediation activities where confirmation samples may be collected include:

- Sites with specific worker allegations of misrepresentation of data (e.g., Building 351A Crawl Space).
- Select anomalous areas identified by statistical testing for sampling.

The radiological data will also serve to validate remedial decisions regarding the current property condition and decisions regarding property transfer.

Confirmation sampling activities will include the following:

- Radiological measurements in the field as described in the separate Radiological Work Plan.
- Advancing direct-push borings for confirmation soil sample collection.
- Excavating test pits for confirmation soil sample collection.
- Hand augering at locations where the direct-push technology rig and/or excavator cannot gain access for confirmation soil sample collection.
- Samples will be analyzed for primary radionuclides including Cesium-137 (Cs-137), Radium-226 (Ra-226), Bismuth-214 (Bi-214), Lead-214 (Pb-214), Potassium-40 (K-40), Actinium (Ac-228), Bismuth-212 (Bi-212), and Lead-212 (Pb-212). A subset of samples will also be analyzed for the secondary radionuclide Total Strontium/Strontium-90 (Sr-90). Additional radionuclides may be analyzed on an as-needed basis and include Americium (Am-241), Cobalt-60 (Co-60), Europium-152 (Eu-152), Europium-154 (Eu-154), Plutonium-238 (Pu-238), Plutonium-239 (Pu-239).
- Radiological data obtained will be compared to Derived Concentration Guideline Levels to determine if radionuclide concentrations exceed regulatory criteria. The Derived Concentration Guideline Levels are the release criteria for the project as specified in the Action Memorandum for Time Critical Removal Action Table 1, column containing “Soil Residential (pCi/g)” (Navy, 2006). The release criteria were developed based on the *Multi-Agency Radiation Site Survey and Investigation Manual* guidance and are presented in Table 1 of **Worksheet #17**.

The primary objective of this SAP is to provide guidance on soil sampling, laboratory analysis, and quality assurance for specific sampling activities pertaining to the confirmation survey at HPNS. This SAP will be used as a reference document by all field and laboratory personnel engaged in the soil sampling and analysis activities for the confirmation survey sampling activities. The SAP is an attachment to the Radiological Work Plan that contains additional information needed to execute the radiological fieldwork. Using this SAP as guidance, standalone Task-specific Sampling Plans (TSPs) will be developed for each site or area that will be addressed as part of the confirmation survey. Each TSP will be provided to the Navy Remedial Project Manager and Navy Quality Assurance

Officer for review and approval prior to implementation and will include the following information as applicable to the task:

- Task description, including the specific location history, purpose of the task, and the radionuclides of concern
- Site-specific sample locations, sample depths, number of samples, and specific sample analysis
- Data quality objectives defined to a level sufficient to ensure that the data obtained will support the goals of the task
- An activities plan consisting of a soil sample confirmation description and discussion of potential additional activities necessary to support the soil sampling
- Specific identification of variations (required either based on site conditions or technical requirements), if any, to the SAP, including the work plan requirement, the required variations, and the technical justification for the variations
- Specific survey figures (as required) that provide sampling locations and other figures necessary to support the activity
- Attachments (as necessary) to provide further description, information or delineation of the task activities

Included in this SAP are general data quality objectives, field sampling procedures, quality assurance/quality control requirements, and data gathering methods that will be used to ensure that all data collected are precise, accurate, representative, complete, and comparable to meet their intended use.

This SAP will be included as an attachment to the HPNS Radiological Work Plan, which will contain detailed information on the radiological support activities that will be conducted alongside the soil sampling activities outlined in this SAP. All radiological support work will be performed in accordance with the attendant radiological SOPs which will be included as an attachment to the Radiological Work Plan.

Using this SAP as a guide, TSPs will be prepared for each site or area selected for additional sampling, and in addition to the information outlined above, each TSP will include site specific sample locations, sample depths, number of samples and specific sample analysis. Site figures showing the exact sample locations will be included in each TSP.

Organization of the SAP

This SAP was developed in accordance with the following guidance documents:

- *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
- *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA, 2005)
- *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)

This SAP is organized according to the *Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP) (USEPA, 2005). The UFP-QAPP is the outcome of the Intergovernmental Data Quality Task Force. It is the companion to the *Uniform Federal Policy for Implementing Environmental Quality Systems* (UFP-QS). The UFP-QS was developed to consistently implement the quality system requirements of American National Standards Institute (ANSI)/American Society for Quality E4-2004 Quality Systems for Environmental Data and Technology Programs (ANSI, 2004).

A list of the 37 UFP-QAPP worksheets, included in this Tier I SAP, is provided in the Table of Contents and **Worksheet #2**.

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Contents

Executive Summary **5**

Acronyms and Abbreviations **11**

SAP Worksheet #1—Title and Approval Page 1

Executive Summary 5

Acronyms and Abbreviations 11

SAP Worksheet #2—SAP Identifying Information 15

SAP Worksheet #3—Distribution List 19

SAP Worksheet #4—Project Personnel Sign-off Sheet 21

SAP Worksheet #5—Project Organizational Chart 23

SAP Worksheet #6—Communication Pathways 25

SAP Worksheet #7—Personnel Responsibilities and Qualifications 29

SAP Worksheet #8—Special Personnel Training Requirements 33

SAP Worksheet #9—Project Scoping Session Participants Sheet 35

SAP Worksheet #10—Conceptual Site Model 37

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements 43

SAP Worksheet #12—Field Quality Control Samples - Soil 45

SAP Worksheet #13—Secondary Data Criteria and Limitations 47

SAP Worksheet #14—Summary of Project Tasks 49

SAP Worksheet #15a—Reference Limits and Evaluation Soil Gamma Spectroscopy 57

SAP Worksheet #15b—Reference Limits and Evaluation Soil Alpha Spectroscopy 59

SAP Worksheet #15c—Reference Limits and Evaluation Soil Gas Flow Proportional Counting 60

SAP Worksheet #15d—Reference Limits and Evaluation Water Gamma Spectroscopy 61

SAP Worksheet #15e—Reference Limits and Evaluation Water Alpha Spectroscopy 63

SAP Worksheet #15f—Reference Limits and Evaluation Water Gas Flow Proportional Counting 64

SAP Worksheet #16—Project Schedule/Timeline 65

SAP Worksheet #17—Sampling Design and Rationale 67

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements 69

SAP Worksheet #19—Field Sampling Requirements 71

SAP Worksheet #20—Field Quality Control Sample Summary 73

SAP Worksheet #21—Project Sampling SOP References 75

SAP Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection 77

SAP Worksheet #23—Analytical SOP References 79

SAP Worksheet #24—Analytical Instrument Calibration 81

SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection 83

SAP Worksheet #26—Sample Handling System 85

SAP Worksheet #27—Sample Custody Requirements 87
SAP Worksheet #28a—Laboratory QC Samples 89
SAP Worksheet #28b—Laboratory QC Samples 90
SAP Worksheet #28c—Laboratory QC Samples 91
SAP Worksheet #29—Project Documents and Records 93
SAP Worksheet #30—Analytical Services 95
SAP Worksheet #31—Planned Project Assessments 97
SAP Worksheet #32—Assessment Findings and Corrective Action Responses 99
SAP Worksheet #33—QA Management Reports 101
SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process 103
SAP Worksheet #37—Usability Assessment 105
References 109

Attachments

1 Project Scoping Meeting Minutes
2 Example Test Pit Log
3 Example Soil Boring Log
4 Field SOPs
5 Laboratory SOPs
6 Laboratory Certifications
7 Technical Systems Audit Checklist

Tables

2-1 Previous Site Work
2-2 UFP-QAPP Crosswalk
17-1 Release Criteria

Figures

10-1 Installation Location
10-2 Site Layout

Acronyms and Abbreviations

%R	percent recovery
AM	Action Memorandum
ANSI	American National Standards Institute
APP	Accident Prevention Plan
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRAC	Base Realignment and Closure
BEC	BRAC Environmental Coordinator
BLTL	Business Line Team Leader
CA	corrective action
CAS	Chemical Abstract System
CCV	continuing calibration verification
CH2M	CH2M HILL, Inc.
CLP	Contract Laboratory Program
Cs	Cesium
CSO	Caretaker Site Office
DCGLs	Derived Concentration Guideline Level
DoD	Department of Defense
DPT	direct-push technology
DQA	Data Quality Assessment
DQI	data quality indicator
DQO	data quality objective
DTSC	California Department of Toxic Substances Control
EB	equipment blank
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
EWI	Environmental Work Instruction
GFPC	gas flow proportional counting
G-RAM	general radioactive material
HP	Hunters Point
HRA	Historical Radiological Assessment
HPNS	Hunters Point Naval Shipyard
ICAL	initial calibration
ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
IR	Installation Restoration
KCH	CH2M HILL Kleinfelder, A Joint Venture
LCS	laboratory control sample
LFE	LFE Environmental Analysis Laboratories, Inc.
LLMW	low-level mixed waste

LLRW	low-level radioactive waste
LRPM	Lead Remedial Project Manager
MB	method blank
MDC	minimum detectable concentration
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NAVFAC SW	Naval Facilities Engineering Command Southwest
NAVSEA	Naval Sea Systems Command
Navy	Department of the Navy
NEESA	Naval Energy and Environmental Support Activity
NIRIS	Naval Installation Restoration Information Solution
NRDL	Naval Radiological Defense Laboratory
OCII	Office of Community Investment and Infrastructure
ORR	Operational Readiness Review
PAL	project action limit
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
pCi/g =	picocuries per gram
PM	Project Manager
PSL	project screening limit
PT	proficiency testing
Pu	Plutonium
PUC1	Parcel Unit 1
QA	quality assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
QSM	Quality Systems Manual for Environmental Laboratories
RASO	Radiological Affairs Support Office
RER	relative error ratio
RPD	relative percent difference
ROICC	Resident Officer in Charge of Construction
RPM	Remedial Project Manager
RTC	Response to Comment
SAP	sampling and analysis plan
SB	subsurface soil
SDG	sample delivery group
SF	San Francisco
SFDPH	San Francisco Department of Public Health
SOP	standard operating procedure
spec	spectroscopy
SS	surface soil
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan

STC	Senior Technical Consultant
TBD	to be determined
the Bay	San Francisco Bay
Triple A	Triple A Machine Shop, Inc.
TSA	Technical Systems Audit
TSP	Task-specific Sampling Plan
TtEC	Tetra Tech EC, Inc.
UFP	Uniform Federal Policy
USEPA	United States Environmental Protection Agency
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region

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SAP Worksheet #2—SAP Identifying Information

Site Name/Number:	Hunters Point Naval Shipyard (HPNS), San Francisco, California
Operable Unit:	Not Applicable (N/A)
Contractor Name:	CH2M HILL, Inc. (CH2M)
Contract Number:	N62470-16-D-9000
Contract Title:	Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Radiological Data Evaluation and Confirmation Survey, Former Hunters Point Naval Shipyard
Work Assignment Number:	Contract Task Order Number FZ12

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the following guidance documents:
   - *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
   - *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA, 2005)
   - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
2. Identify regulatory program:
   - Comprehensive Environmental Response, Compensation, and Liability Act.
3. This SAP is a project-specific SAP.
4. List dates of scoping sessions that were held:
   - The Department of the Navy (Navy) Base Realignment and Closure (BRAC) Project Management Office (PMO) held project kickoff meetings on November 17 and 22, 2016, and one with the regulators including the U.S. Environmental Protection Agency (USEPA), California Department of Toxic Substances Control (DTSC), Office of Community Investment and Infrastructure (OCII), San Francisco Department of Public Health (SFDPH), and California Regional Water Quality Control Board, San Francisco Bay Region (Water Board) on December 7, 2016.
5. List dates and titles of documents that are relevant to the current investigation:
   - Previous site work relevant to the current investigation is summarized in **Table 2-1**. **Worksheet #10** includes a summary of the findings from previous investigations.

Table 2-1. Previous Site Work

Reference Title	Date	Author
Radiation Safety Section and Naval Radiological Defense Laboratory (NRDL) surveys and decontamination of OPERATION CROSSROADS ships and drydocks	1946-1948	NRDL
NRDL surveys to decommission NRDL buildings at HPNS	1955	NRDL
NRDL survey for dis-establishment of NRDL	1969	NRDL
Atomic Energy Commission survey to verify NRDL's survey results and release buildings for reuse	1969-1970	Atomic Energy Commission

SAP Worksheet #2—SAP Identifying Information (continued)

Table 2-1. Previous Site Work

Reference Title	Date	Author
HPNS survey for base closure	1974	HPNS
LFE Environmental Analysis Laboratories, Inc. (LFE) survey of Building 815	1978	LFE
Radiation and Safety Office (RASO) confirmation survey of LFE's survey findings for Building 815	1978	RASO
RASO survey of former NRDL buildings	1978	RASO
RASO resurvey of Buildings 364, 815, and 816	1979	RASO
USEPA harbor survey at Naval Nuclear Propulsion Program's request	1986	EPA
Harding Lawson Associates site reconnaissance	1988-1989	Harding Lawson Associates
Surveys conducted for the Remedial Investigation program in four phases: Phases I through IV included the 1997 Parcel E radiation risk assessment; and, the 1999 to 2001 interim investigations between the Phase IV and Phase V investigations	1991-2001	Multiple
Parcel D Feasibility Study Draft Final Report	1997	Levine-Fricke Recon, Inc. PRC Environmental Management
Phase V investigations and removal actions	2001-2003	
Wetlands Delineation and Functions and Valves Assessment, HPNS, San Francisco, California	2002	Tetra Tech EC, Inc. (TtEC)
Draft Parcel E Standard Data Gaps Investigation	2003	
Historical Radiological Assessment, Volume II	2004	Naval Sea Systems Command (NAVSEA)
Basewide Radiological Work Plan	2005	TtEC
Basewide Radiological Removal Action, Action Memorandum-Revision 2006, HPNS, San Francisco, California	2006	TtEC
Basewide Radiological Work Plan, Revision 1	2007	TtEC
Project Work Plan - Basewide Storm Drain and Sanitary Sewer Removal, HPNS, San Francisco, California	2008	TtEC
Basewide Archaeological Monitoring and Discovery Plan	2009	TtEC
Survey Unit Project Reports Abstract	2010	TtEC

SAP Worksheet #2—SAP Identifying Information (continued)

6. Organizational partners (stakeholders) and connection with lead organization:
   - The stakeholders include DTSC, City of San Francisco (includes OCII/SFDPH), USEPA, and Water Board.
7. Lead organization:
   - The lead organization for the project is the Navy. The Navy uses the information gathered to make decisions in conjunction with the stakeholders.
8. If any required SAP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:
   - A list of the worksheets in this SAP is provided in **Table 2-2**.

Table 2-2. UFP-QAPP Crosswalk

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information (if applicable)
A. Project Management		
Documentation		
1	Title and Approval Page	
2	SAP Identifying Information	
3	Distribution List	
4	Project Personnel Sign-off Sheet	
Project Organization		
5	Project Organizational Chart	
6	Communication Pathways	
7	Personnel Responsibilities Table	
8	Special Personnel Training Requirements Table	
Project Planning/Problem Definition		
9	Project Scoping Session Participants Sheet	
10	Conceptual Site Model	
11	Project Quality Objectives/Systematic Planning Process Statements	
12	Field Quality Control (QC) Samples	
13	Secondary Data Criteria and Limitations Table	
14	Summary of Project Tasks	
15	Reference Limits and Evaluation Table	
16	Project Schedule/Timeline Table	

SAP Worksheet #2—SAP Identifying Information (continued)

Table 2-2. UFP-QAPP Crosswalk

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information (if applicable)
B. Measurement Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	
18	Location-Specific Sampling Methods/Standard Operating Procedure (SOP) Requirements Table	
19	Field Sampling Requirements Table	
20	Field QC Sample Summary Table	
21	Project Sampling SOP References Table	
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	
Analytical Tasks		
23	Analytical SOP References Table	
24	Analytical Instrument Calibration Table	
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	
Sample Collection		
26	Sample Handling System	
27	Sample Custody Requirements	
Quality Control Samples		
28	Laboratory QC Samples Table	
Data Management Tasks		
29	Project Documents and Records Table	
30	Analytical Services Table	
C. Assessment Oversight		
31	Planned Project Assessments Table	
32	Assessment Findings and Corrective Action Responses Table	
33	Quality Assurance (QA) Management Reports Table	
D. Data Review		
34-36	Data Verification and Validation (Steps I and IIa/IIb) Process Table	
37	Usability Assessment	

SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
Danielle Janda	Lead Remedial Project Manager (LRPM)	Navy BRAC	(619) 524-6041	danielle.janda@navy.mil
Joe Arlauskas	Quality Assurance Officer (QAO)	Naval Facilities Engineering Command Southwest (NAVFAC SW)	(619) 532-4125	joseph.arlauskas@navy.mil
George (Patrick) Brooks	Business Line Team Leader (BLTL), Project Manager	Navy BRAC	(619) 524-5724	george.brooks@navy.mil
Derek Robinson	BRAC Environmental Coordinator (BEC)	Navy BRAC	(619) 524-6026	derek.robinson@navy.mil
Zachary Edwards	Environmental Program Manager, Health Physicist	NAVSEA RASO	(757) 887-7762	zachary.edwards@navy.mil
Matthew Slack	Environmental Program Manager, Health Physicist	NAVSEA RASO	(757) 887-4212	matthew.slack@navy.mil
Nina Bacey	RPM	DTSC	(510) 540-2480	juanita.bacey@dtsc.ca.gov
Janet Naito	Branch Manager, Cleanup	DTSC	(510) 540-3833	janet.naito@dtsc.ca.gov
Tina Low	RPM/Technical Staff Lead	Water Board	(510) 622-5682	tina.low@waterboards.ca.gov
Scott Hay	Radiological Lead	Cabrera	(702) 236-8401	shay@cabreraservices.com
Anita Dodson	Program Chemist	CH2M	(757) 671-6218	anita.dodson@ch2m.com
Kim Henderson	Project Manager (PM)	CH2M	(619) 272-7209	kimberly.henderson@ch2m.com
Kira Sykes	Radiological Lead	CH2M	(503) 872-4510	kira.sykes@ch2m.com
Alan Bradford	Senior Technical Consultant	CH2M	(714) 435-6297	alan.bradford@ch2m.com
Mark Cichy	Project Chemist	CH2M	(530) 229-3274	mark.cichy@ch2m.com
To be determined (TBD)	Field Team	CH2M	TBD	TBD
TBD	Field Team Leader	CH2M	TBD	TBD

SAP Worksheet #3—Distribution List (continued)

Name of SAP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
Loren Kaehn	Health and Safety Manager	CH2M	(208) 383-6212	loren.kaehn@ch2m.com
TBD	Site Safety and Health Officer (SSHO)	CH2M	TBD	TBD
Alex Lopez	Project Manager/Licensed Radiological Safety Officer (PjM/RSO)	PermaFix	970-778-0449	alopez@perma-fix.com
Tamsen Drew	Senior PM/OCII Staff Lead	OCII (San Francisco [SF])	(415) 749-2539	tamsen.drew@sfgov.org
Amy Brownell	Staff Lead Technical SFDPH	SFDPH	(415) 252-3967	amy.brownell@sfdph.org
Lily Lee	RPM/Staff Technical Lead	USEPA	(415) 847-4187	lee.lily@epa.gov
John Chesnutt	Section Manager, U.S. Army, Navy	USEPA	(415) 972-3005	chesnutt.john@epa.gov
TBD	Data Validation PM	TBD	TBD	TBD
Valerie Davis	Analytical Laboratory PM	GEL Laboratories, LLC	(843) 556-8171	team.davis@gel.com

Notes:

TBD cells will be populated with information after personnel are selected, prior to fieldwork.

SAP Worksheet #4—Project Personnel Sign-off Sheet

Name	Organization/Title/Role	Telephone Number (optional)	Signature/email receipt	SAP Section Reviewed	Date SAP Read
Kim Henderson	CH2M/PM	(619) 272-7209			
Alan Bradford	CH2M/Senior Technical Consultant (STC)	(714) 435-6297			
TBD	CH2M/Field Team Leader	TBD			
Mark Cichy	CH2M/Project Chemist	(530) 229-3274			
Monica Calabria	CH2M/Data Manager	(610) 399-3860			
TBD	CH2M/SSHO	TBD			
Valerie Davis	GEL Laboratories, LLC/Laboratory PM	(843) 556-8171			
TBD	TBD/Data Validation PM	TBD			
TBD	CH2M/Sampling Personnel	TBD			

Notes:

The sampling personnel will read the appropriate sections of this document before performing activities related to this SAP. The completed sign-off worksheet will be maintained in the CH2M project file.

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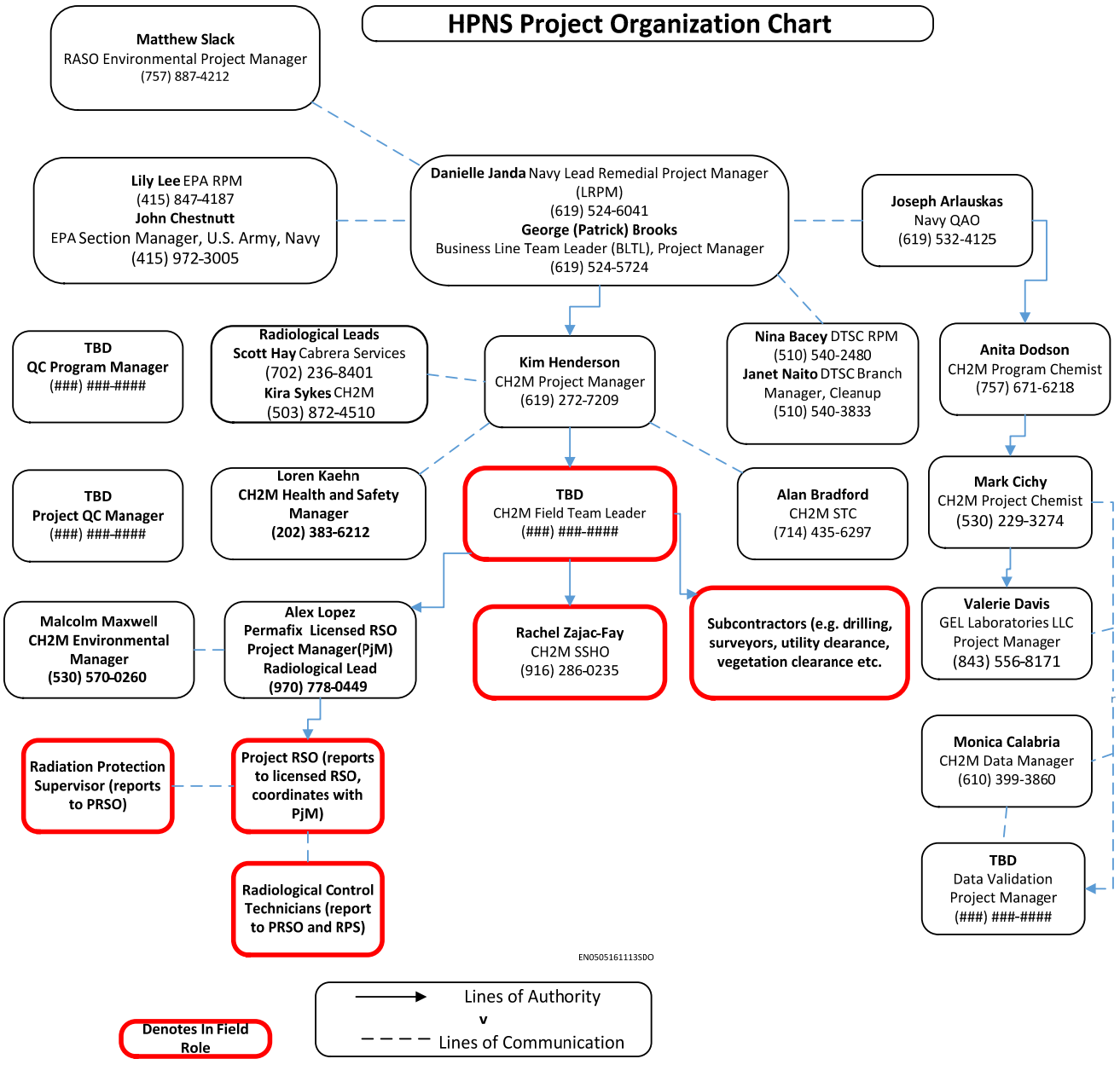
SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
Authorization for CH2M to initiate fieldwork	Navy LRPM/BLTL	Danielle Janda/ George (Patrick) Brooks	(619) 524-6041/ (619) 524-5724	CH2M PM communicates either verbally or by email with earliest schedule possible for fieldwork to commence. Navy LRPM/BLTL provides CH2M PM with written instruction to proceed upon completing coordination with Contracting Officer.
USEPA point-of-contact with Navy LRPM/BLTL	USEPA RPM	Lily Lee	(415) 847-4187	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
USEPA point-of-contact with Navy LRPM/BLTL	USEPA Section Manager, U.S. Army, Navy	John Chesnutt	(415) 972-3005	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
DTSC point-of-contact with Navy LRPM/BLTL	DTSC RPM	Nina Bacey	(510) 540-2480	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
DTSC point-of-contact with Navy LRPM/BLTL	DTSC Branch Manager, Cleanup	Janet Naito	(510) 540-3833	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
NAVSEA RASO point-of-contact with Navy LRPM/BLTL	NAVSEA RASO, Environmental Program Manager, Health Physicist	Zachary Edwards	(757) 887-7762	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
NAVSEA RASO point-of-contact with Navy LRPM/BLTL	NAVSEA RASO, Environmental Program Manager, Health Physicist	Matthew Slack	(757) 887-4212	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
Water Board point-of-contact with Navy LRPM/BLTL	Water Board	Tina Low	(510) 622-5682	Reports and other project-related information are submitted by the Navy for review and comments by the agency.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
OCII (SF) point-of-contact with Navy LRPM/BLTL	OCII (SF) PM	Tamsen Drew	(415) 749-2539	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
SFDPH point-of-contact with Navy LRPM/BLTL	SFDPH Staff Lead	Amy Brownell	(415) 252-3967	Reports and other project-related information are submitted by the Navy for review and comments by the agency.
CH2M point-of-contact with Navy LRPM/BLTL	CH2M PM	Kim Henderson	(619) 272-7209	Materials and information about the project are forwarded to the Navy LRPM/BLTL by the PM.
CH2M point-of-contact with Navy LRPM/BLTL	CH2M Radiological Lead	Kira Sykes	(503) 872-4510	Materials and information about the project are forwarded to the Navy LRPM/BLTL by the PM.
CH2M point-of-contact with Navy LRPM/BLTL	Cabrera Radiological Lead	Scott Hay	(702) 236-8401	Materials and information about the project are forwarded to the Navy LRPM/BLTL by the PM.
CH2M point-of-contact with Navy LRPM/BLTL	Permafix Lead Project Manager/Licensed Radiological Safety Officer (PjM/RSO)	Alex Lopez	970-778-0449	Materials and information about the project are forwarded to the Navy LRPM/BLTL by the PM.
CH2M point-of-contact with Navy QAO	CH2M Program Chemist	Anita Dodson	(757) 671-6218	Quality-related materials and information about the project are forwarded to the Navy QAO by the Program Chemist.
SAP amendments	CH2M Program Chemist	Anita Dodson	(757) 671-6218	Any changes to the SAP and/or TSPs are submitted in writing to the Navy QAO, who must approve the changes prior to implementation.
SAP amendment approvals	Navy QAO	Joseph Arlauskas	(619) 532-4125	Issues final approval of SAP amendments to Program Chemist via signed approval form (portable document format is acceptable). Concurrence from the Navy LRPM/BLTL.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
Revising sampling program (adding or removing sampling location or revising analytical suite)	CH2M PM	Kim Henderson	(619) 272-7209	Changes to the sampling program are submitted in writing as a field change request or proposed SAP amendment to the Navy QAO, who must approve the changes prior to implementation.
Field or analytical corrective actions	Program Chemist CH2M	Anita Dodson	(757) 671-6218	The need for corrective actions (CAs) is assessed by the Program Chemist, who notifies the PM and Navy QAO by phone or e-mail within 2 business days. PM notifies the Navy LRPM/BLTL and Field Team Leader (field issues) or Project Chemist (analytical issues) by phone or e-mail within 2 business days. The Navy LRPM/BLTL notifies DTSC by phone or e-mail, within 2 business days of their notification.
Field progress reports	Field Team Leader CH2M	TBD	TBD	Daily field progress reports will be prepared by the Field Team Leader and submitted to the PM by phone or email.
Stop work issues	Field Team Leader CH2M	TBD	TBD	Field Team leader notifies PM about any stopped work that occurs. All field personnel have stop work authority based on the Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP). Joseph Arlauskas, Navy QAO, or representative, has authority to stop work if quality-related compliance issues are identified, or if there is noncompliance with field QC protocols, as specified in this SAP.
	Navy QAO	Joseph Arlauskas	(619) 532-4125	
Field implementation of SAP changes	PM CH2M	Kim Henderson	(619) 272-7209	PM notifies Field Team Leader by phone and e-mail of changes at least 2 days prior to field implementation.
Release of field data	Field Team Leader CH2M	TBD	TBD	Field data are reviewed by the Field Team Leader and are transmitted by e-mail or hard copy shipping to the PM.
Field deviations from the SAP	Field Team Leader CH2M	TBD	TBD	Field Team Leader notifies PM and Program Chemist by phone or e-mail within 2 days of the SAP deviation (nature of deviation and technical justification).

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure (timing, pathway to and from, etc.)
Analytical deviations from the SAP or reporting analytical data quality issues	PM GEL	Valerie Davis	(843) 556-8171	Laboratory subcontractor notifies Project Chemist within 24 hours by phone or e-mail and documents SAP deviations in the final analytical data report.
Analytical data validation issues	Data Validation PM TBD	TBD	TBD	Analytical data validation subcontractor notifies Project Chemist within 2 business days and documents issues in the data validation report.
Notification of non-usable analytical data	Program Chemist CH2M	Anita Dodson	(757) 671-6218	If the laboratory or the project team identify problems that affect the usability of the data (i.e., the data are rejected or the data quality objectives [DQOs] are not met), the CH2M Program Chemist or Project Chemist will notify the PM and Navy QAO within 24 hours. The PM will notify the Navy LRPM/BLTL within 24 hours.
Release of analytical data to CH2M	Project Chemist CH2M	Mark Cichy	(530) 229-3274	No analytical data can be released until validated analytical data are approved by the Project Chemist.
Report submittal to regulatory agencies	Navy LRPM/BLTL	Danielle Janda/George (Patrick) Brooks	(619) 524-6041/ (619) 524-5724	Navy LRPM/BLTL receives report from CH2M and submits to DTSC. Navy RPM also provides copies, as appropriate, to other Navy contractors.
Response to regulatory comments	Navy LRPM/BLTL	Danielle Janda/George (Patrick) Brooks	(619) 524-6041/ (619) 524-5724	Navy LRPM/BLTL receives regulatory comments on submitted Work Plan and Field Activity Report and coordinates responses with CH2M, as necessary.

SAP Worksheet #7—Personnel Responsibilities and Qualifications

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Danielle Janda/George (Patrick) Brooks	Navy LRPM/BLTL	NAVFAC SW	• Performs project management • Oversees the project cost and schedule • Provides overall direction for project • Provides authorization for work to be performed • Acts as liaison with regulatory agencies, including submittal of documents • Acts as liaison with other Navy departments • Oversees protocols for disposal of investigation-derived waste (IDW)	
Joseph Arlauskas	Navy QAO	NAVFAC SW	• Provides governmental oversight of the project QA Program • Provides quality-related directives through Contracting Officer representative • Acts as point-of-contact for matters concerning QA and the Navy's Laboratory QA Program • Coordinates training on matters pertaining to generation and maintenance of quality of data • Authorizes the suspension of project execution if QA requirements are not adequately followed	
Zachary Edwards	Environmental Program Manager, Health Physicist	NAVSEA RASO	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	
Matthew Slack	Environmental Program Manager, Health Physicist	NAVSEA RASO	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	
Lily Lee	USEPA RPM	USEPA	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	

SAP Worksheet #7—Personnel Responsibilities and Qualifications (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
John Chestnutt	USEPA Section Manager, U.S. Army, Navy	USEPA	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	
Nina Bacey	RPM	DTSC	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	
Janet Naito	Branch Manager, Cleanup	DTSC	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	
Tina Low	RPM/Technical Staff Lead	Water Board	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	
Tamsen Drew	Senior PM/OCII Staff Lead	OCII (SF)	• Reviews reports and other project-related information submitted by the Navy LRPM/BLTL and provides comments	
Amy Brownell	Staff Lead Technical SFDPH	SFDPH	• Reviews reports and other project-related information submitted by the Navy RPM and provides comments	
Scott Hay	Radiological Lead	Cabrera	• Provides radiological oversight for project and team • Reviews reports and other project-related information • Communicates with and leads health physicists	
Kira Sykes	Radiological Lead	CH2M HILL	• Provides radiological oversight for project and team • Reviews reports and other project-related information • Communicates with and leads health physicists	
Loren Kaehn	Health and Safety Manager	CH2M	• Oversees preparation of company safety programs and compliance • Reviews SSHP • Acts as a liaison between PM and project-specific safety personnel	

SAP Worksheet #7—Personnel Responsibilities and Qualifications (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Kim Henderson	PM	CH2M	• Issues stand-down order when necessary • Establishes an overall records management system • Implements the approved project-specific plans • Evaluates project-specific procedures and plans • Evaluates the project schedule and budget	
Anita Dodson	Program Chemist	CH2M	• Serves as a point-of-contact for the Navy QAO • Reviews and approves QA/QC plans and revisions • Periodically evaluates the effectiveness of the QA/QC plans by conducting surveillances, audits, or management assessments • Assigns, directs, and supports the QA/QC staff • Trains, qualifies, and evaluates the personnel according to the QA/QC plans • Reviews project-specific SAPs as required • Directs QA audits • Reviews field deviations from the SAP	
TBD	SSHO	CH2M	• Implements SSHP; verifies that field personnel have required training and attend daily safety meetings • Is lead for identifying, communicating, and, as appropriate, addressing CAs for encountered hazards not initially addressed in the SSHP • Communicates and reports health and safety issues to the Health and Safety Manager	
TBD	Field Team Leader	CH2M	• Directs field operations • Documents field activities on Daily field progress reports • Reviews field sampling data • Prepares field deviations from the SAP	

SAP Worksheet #7—Personnel Responsibilities and Qualifications (continued)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Mark Cichy	Project Chemist	CH2M	• Participates in development of project-specific SAP • Implements contract requirements for analytical data collection • Implements analytical data QC procedures • Reviews analytical data prior to use • Coordinates analytical data validation • Reviews analytical data validation reports • Supports technical memorandum preparation and assesses whether project specifications have been met	
Monica Calabria	Data Manager	CH2M	• Imports sample and analytical data into a database system • Provides sample and analytical data for technical memorandum production • Transmits validated analytical data to the Navy via the Naval Installation Restoration Information Solution (NIRIS)	
Valerie Davis	Analytical Laboratory PM	GEL	• Oversees analytical laboratory analyses and data reporting (primary laboratory)	
TBD	Analytical Data Validation PM	TBD	• Oversees validation of analytical data, preparation of analytical data validation reports, and electronic data deliverable (EDD) preparation with validation qualifiers	

SAP Worksheet #8—Special Personnel Training Requirements

Project Function	Specialized Training by Title or Description of Course	Training Provider	Training Date	Personnel/ Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates
N/A	N/A	N/A	N/A	N/A	N/A	N/A

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SAP Worksheet #9—Project Scoping Session Participants Sheet

Project Name:	Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Radiological Data Evaluation and Confirmation Survey, Former Hunters Point Naval Shipyard	**Site Name:**	HPNS
Projected Date(s) of Sampling:	2017	**Site Location:**	San Francisco, CA
Project Manager:	Kim Henderson (619) 272-7209		
Date of Session:	December 7, 2016		
Scoping Session Purpose:	To introduce team members, discuss radiological data evaluation and community outreach activities, and gain feedback, input, and buy-in from stakeholders.		

Name	Title	Affiliation	Phone #	Email Address	Project Role
Danielle Janda	LRPM	Navy BRAC	(619) 524-6041	danielle.janda@navy.mil	LRPM
Derek Robinson	BEC	Navy BRAC	(619) 524-6026	derek.robinson@navy.mil	BEC
Pat Brooks	BLTL/PM	Navy BRAC	(619) 524-5724	george.brooks@navy.mil	PM and BLTL
Bill Franklin	Public Affairs Officer	Navy BRAC	(619) 524-5433	william.d.franklin@navy.mil	Com Inv Lead
Lily Lee	RPM	USEPA	(415) 947-4187	lee.lily@epa.gov	Staff Lead Technical USEPA
Jackie Lane	Com Inv Coordinator	USEPA	(415) 972-3236	lane.jackie@epa.gov	Staff Lead Com Inv USEPA
David Yogi	Manager, Com Inv	USEPA	(415) 972-3350	yogi.david@epa.gov	Mid Manager Com Inv USEPA
Tamsen Drew	Senior PM/OCII Staff Lead	OCII (SF)	(415) 749-2539	tamsen.drew@sfgov.org	Senior PM/OCII Staff Lead
Amy Brownell	Engineer	SFDPH	(415) 252-3967	amy.brownell@sfdph.org	Staff Lead Technical SFDPH
Scott Hay	Principal Health Physicist	CS	(410) 332-8177	shay@cabreraservices.com	Principal Health Physicist
Janet Naito	Branch Manager, Cleanup	DTSC	(510) 540-3833	janet.naito@dtsc.ca.gov	Mid Manager Technical DTSC
Nina Bacey	RPM	DTSC	(510) 540-2480	juanita.bacey@dtsc.ca.gov	Staff Lead Technical DTSC
Sheetal Singh	Mid Manager CDPH	CDPH EMB	(916) 449-5691	sheetl.singh@cdph.ca.gov	Mid Manager CDPH
Robert Kirkbright	Program Manager	CH2M	(619) 687-0120 x37276	robert.kirkbright@ch2m.com	Program Manager

SAP Worksheet #9—Project Scoping Session Participants Sheet (continued)

Name	Title	Affiliation	Phone #	Email Address	Project Role
Jeff Wong	--	CDPH RHB	--	jeff.wong@cdph.ca.gov	--
Tina Low	RPM	Water Board	(510) 622-5682	tina.low@waterboards.ca.gov	Staff Lead Technical Water Board
Kellie Koenig	Vice President	CH2M	(619) 272-7217	kellie.koenig@ch2m.com	Vice President
Adam Engel	Health Physicist	CH2M	(619) 272-7286	adam.engel@ch2m.com	Data Reviewer
LCDR Soric	--	NAVSEA RASO	--	--	--
Lindsey Land	--	--	--	--	--
Matthew Slack	Environmental PM	NAVSEA RASO	(757) 887-4212	matthew.slack@navy.mil	Technical Expert Navy
Dr. Stephen Doremus	Director	NAVSEA RASO	(757) 887-4692	steve.doremus@navy.mil	Technical Expert Navy
Zachary Edwards	Manager, Health Physicist	NAVSEA RASO	(757) 887-7762	zachary.edwards@navy.mil	Technical Expert Navy
Jana Dawson	Health Physicist (Techlaw Contractor)	USEPA	--	jdawson@techlawinc.com	Technical Expert USEPA
Karla Brasaemle	Geologist (Techlaw Contractor)	USEPA	--	kbrasaemle@techlawinc.com	Technical Expert USEPA
Mark Luckhardt	--	Five Point	--	--	--

Comments/Decisions:

A detailed summary of the meeting is included in **Attachment 1**.

Action Items:

- Determine if pre-2006 data was used for decision making.
- Provide library of compiled questions and answers on community outreach to share with team.
- Plan twice a month Community Outreach Team check-in meeting.
- Email copy of Draft Radiological Community Engagement Plan Communications Plan to RASO.

Consensus Decisions:

- USEPA, DTSC, and the project team agreed that if the pre-2006 data was superseded by other work done after 2006, it does not need to be analyzed.
- Statistical tests will identify anomalies in the data, including running tests designed to identify instances where data may have been falsified. It was agreed that areas of highest potential risk should be the priority.

SAP Worksheet #10—Conceptual Site Model

Site History

HPNS lies entirely within the corporate boundaries of the City and County of San Francisco, California, near the County's southern boundary with San Mateo County (**Figure 10-1**). It is located on San Francisco Bay in the southeast comer of San Francisco. The site encompasses approximately 848 acres, including approximately 416 acres on land, at the point of a high, rocky, 2-mile-long peninsula projecting southeastward into the San Francisco Bay (the Bay). HPNS is divided into seven parcels which are further broken down into subparcels (**Figure 10-2**). The main Parcels A through E and Parcel G, encompass onshore areas and Parcel F comprises offshore areas. In November 2004, Parcel A was transferred to the City and County of San Francisco. In 2004, the Navy subdivided Parcel E, creating Parcel E-2. Radiologically impacted sites that will be addressed under this SAP include but are not limited to Parcels B, C, D-2, E, G, and utility corridors UC-1, UC-2, and UC-3.

Commercial shipyard activity has taken place on the Hunters Point peninsula since 1868 when the first drydock on the Pacific Coast was constructed there. By 1939, two drydocks and associated support facilities were located on HPNS. The Navy purchased the drydocks and surrounding land from Bethlehem Steel in 1939 and occupied the site in late 1941, creating HPNS. After a significant expansion and buildup during World War II (including the construction of four additional drydocks) the shipyard diversified as a major fleet support center performing ship repair throughout the Korean Conflict. The shipyard operated as a general repair facility specializing in submarines, aircraft carrier overhaul, and ship repair operations through the early 1970s. The workload consisted primarily of the repair and conversion of conventionally powered ships, repair of diesel submarines, and non-radiological work on nuclear-powered ships.

The Navy deactivated HPNS in 1974 and most of the site was then leased to a commercial ship repair company, Triple A Machine Shop, Inc. (Triple A) from 1976 to 1986. Triple A dedicated more than 80 percent of the shipyard to the repair of commercial and naval vessels and subleased unused facilities to private warehousing, industrial, and commercial firms. In 1986, the Navy again assumed control of the shipyard and used it for the docking and repair of several Navy surface ships.

In 1991, HPNS was selected for closure pursuant to the terms of the Defense Base Closure and Realignment Act of 1990. The property will be transferred to the City and County of San Francisco for nondefense use. Closure activities at HPNS involve environmental remediation activities to make the property suitable for transfer. Currently, the BRAC Project Management Office manages the HPNS property. Routine access to the property is controlled by the San Francisco Redevelopment Agency (SFRA) under an agreement with the Navy with the exception of parcels that have been transferred to the City of San Francisco.

Hazardous materials are present at HPNS because of previous shipyard operations. Investigation and cleanup of contamination at HPNS by the Navy has been underway since the 1980s. In 1989, USEPA placed HPNS on the National Priorities List as a Superfund site pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act. Some of the tenants that sublet from Triple A are still operating at HPNS, now under direct leases with the Navy, which has also leased space to the San Francisco Redevelopment Agency, which in turn sublets space to various artists for studios and to divisions of the City of San Francisco Police Department. A limited number of Navy-related entities also maintain operations at the site.

SAP Worksheet #10—Conceptual Site Model (continued)

Radiological History

As part of the environmental investigations being performed to facilitate transfer of HPNS, the Navy prepared a Historical Radiological Assessment (HRA) that documents the history of radiological materials at HPNS. The HRA is presented in two volumes. Volume I (NAVSEA, 2000) addressed radioactivity associated with the Naval Nuclear Propulsion Program and concluded that berthing of nuclear-powered ships at HPNS or work done on these ships resulted in no adverse effects on the human population or the environment. Volume II (NAVSEA, 2004) presented the history of general radioactive material (G-RAM) at HPNS in three primary operational areas:

- Use of G-RAM at HPNS by the naval shipyard and Triple A
- Decontamination activities associated with ships that participated in atomic weapons testing including OPERATION CROSSROADS
- Radiological activities associated with the Radiation Safety Section/Radiation Laboratory Navy Radiological Defense Laboratory

Volume II concluded that areas of known or potential radiological contamination are present at HPNS and identified additional investigation and/or cleanup activities to support the transfer and reuse of the Base. The HRA states that, beginning in the late 1930s, devices incorporating radioluminescent radium paint came into wide use in the Navy. These devices constituted the first G-RAM introduced to HPNS. Other G-RAM used at HPNS as part of routine shipyard activities included:

- Other radioluminescent devices
- Gamma sources for gamma radiography
- Sources for calibrating radiation-detection instruments
- Materials found in items such as smoke detectors, welding rods, and night vision equipment

The HRA reported that the use and/or handling of these materials could have resulted in radiological contamination at HPNS. Some of the ships that participated in atomic weapons testing, including OPERATION CROSSROADS, were brought to HPNS for decontamination. OPERATION CROSSROADS involved detonating two atomic bombs at Bikini Atoll in July 1946. During these tests, a number of ships at the atoll became contaminated with radioactive materials. The Navy concluded that a shipyard environment would be needed to decontaminate many of these ships and HPNS was selected as the principal location for this activity. Consequently, contaminated ships were involved in experimental decontamination efforts at HPNS. Decontamination of these ships and ships involved in other atomic weapons testing was conducted by mechanical methods, such as scraping or sandblasting, and/or chemical methods, such as acid washing. The HRA report stated that decontamination activities and/or the associated waste disposal could have resulted in radiological contamination at HPNS.

In 1946, the Navy created an organization tasked with applying radiological safety throughout the Navy. Initially known as the Radiological Safety Section, this unit was briefly renamed the Radiation Laboratory and ultimately became the NRDL in 1948. The unit was established at HPNS with the original mission of supporting the decontamination efforts on OPERATION CROSSROADS ships. By the time the unit became the NRDL, the mission had expanded to include the study of nuclear weapons effects and development of methods for the protection of Navy personnel and ships. From the 1950s until 1969 when it was closed, NRDL was recognized as a leading radiological research facility. The breadth of the research performed by NRDL included the use of a large number of radionuclides. The use of these materials and the disposal of wastes generated during research activities were identified in the HRA report that could have resulted in radiological contamination at HPNS.

SAP Worksheet #10—Conceptual Site Model (continued)

In accordance with *Multi-Agency Radiation Survey and Site Investigation Manual* (DoD et al., 2000), an "impacted site" is defined as one that has a potential for radioactive contamination based on historical information or is known to have radioactive contamination. Based on the review of historical information regarding radiological operations at HPNS, the HRA concluded that 84 impacted sites were associated with HPNS.

The HRA recommended 56 sites at HPNS for further investigation and remediation by the Navy. Specific recommendations for surveys and/or cleanup at each of the 56 areas were presented in the HRA. However, the Navy also identified several additional sites that require investigation. These include buildings, drydocks, former building sites, outdoor areas, Installation Restoration (IR) sites, ships' berths, the Gun Mole Pier, and the sanitary and storm sewer systems.

In response to the HRA, an Action Memorandum (AM) for Time Critical Removal Action was prepared in 2006, proposing removal actions to substantially eliminate identified pathways of exposure to radioactive contamination for surrounding populations and nearby ecosystems, such as nearby wetlands and the San Francisco Bay (Navy, 2006). To date, several radiological investigations have been conducted and areas of low-level radioactive contaminants addressed through radiological removal and remedial actions.

Five phases of radiological investigations, as well as interim investigations, were performed at HPNS, beginning in 1991 (Navy, 2006). Phases I and II delineated the surface and subsurface distribution of radium-containing devices. Phases III and IV recommended and performed the removal of anomalies near buildings in Parcels D and E. Phase V conducted radiological surveys and remedial actions in Parcels B, C, D, and E.

Historical Radiological Assessment

The HRA was conducted to evaluate all previous uses of radioactive materials at HPNS and to assess their potential to impact the site. The final version of the HRA was issued in August 2004. Based on the recommendations of the HRA, a total of 84 HPNS sites were designated as "impacted." This designation indicates that the site has a potential for radioactive contamination based on historic information or is known to contain radioactive contamination. These impacted sites, broken out by parcel, include:

- Parcel B - 14 sites
- Parcel C - 12 sites
- Parcel D - 19 sites
- Parcel E - 33 sites
- Parcel F - 2 sites
- Off-Base Facilities - 1 site
- Base-Wide Areas- 3 sites

Of the 84 sites designated as impacted in the HRA, 56 sites were recommended for further investigation and remediation by the Navy. In response to this recommendation, radiological actions including TCRAs and site surveys were initiated under the AM and recommended actions implemented as identified in the HRA.

Anomalous Soil Sampling

Several agencies, including the Nuclear Regulatory Commission, were or are currently conducting investigations regarding the possible misrepresentation of data during radiological remediation activities at HPNS. The discrepancy was first identified during a routine telephone call on October 4, 2012. On that call, a Navy official with RASO suggested that samples within a certain investigation area had been collected from locations different than the ones specified in the Final Status Survey Report. The conclusion was based on final systematic (post-remediation) soil sample results reported by the on-site laboratory. These results reported low potassium-40 (K-40) sample activity (i.e., < 5 picocuries per gram) coupled with low activity for radium-226 (Ra-226), bismuth-214

SAP Worksheet #10—Conceptual Site Model (continued)

(Bi-214), and lead-214 (Pb-214) in 36 out of 36 samples. The set of systematic samples were purportedly collected post-remediation at a depth no more than 6 inches below ground surface (bgs). Since the on-site laboratory results were replicated by the off-site gamma spectroscopy laboratory, TestAmerica-St. Louis, the possibility of instrument error as the cause of the anomalous results was ruled out.
TtEC responded to the Navy inquiry by conducting an investigation to determine the source of the discrepancy. Based on the investigation activities above, TtEC initiated a series of corrective actions which are detailed in the *Investigation Conclusion Anomalous Soil Samples at Hunters Point Naval Shipyard (*TtEC*, 2014).*

In 2016, a former TtEC contractor spoke with media; he stated his involvement in the 2012 data misrepresentation and made additional claims about the work done in 2012. As a result of these discrepancies, USEPA and DTSC, the lead federal and state regulatory agencies overseeing HPNS cleanup work, have stated that they will not support the transfer of HPNS property to the City of San Francisco until they are more confident that remedial decisions made were based on factual data. Specifically, USEPA and DTSC directed in the letter that "the Navy will not propose any further transfers of Navy property at HPNS without results of these investigations and/or any other Navy action necessary to clarify the actual potential public exposure to radioactive material at and near the HPNS" (USEPA and DTSC, 2016).

Confirmation Survey ROCs

The confirmation survey is being conducted in order to restore confidence in existing data and provide additional data as needed to support transfer of HPNS property to the City of San Francisco. As such, the ROCs that will be addressed during the confirmation survey include:

- Primary radionuclides including Cesium-137 (Cs-137), Radium-226 (Ra-226), Bismuth-214 (Bi-214), Lead-214 (Pb-214), Potassium-40 (K-40), Actinium (Ac-228), Bismuth-212 (Bi-212), and Lead-212 (Pb-212).
- A subset of samples will also be analyzed for the secondary radionuclide Total Strontium/Strontium-90 (Sr-90).
- Additional radionuclides may be analyzed on an as-needed basis and include Americium (Am-241), Cobalt-60 (Co-60), Europium-152 (Eu-152), Europium-154 (Eu-154), Plutonium-238 (Pu-238), Plutonium-239 (Pu-239).

Site Conditions

Information on the site conditions at HPNS is taken from the *Basewide Storm Drain and Sanitary Sewer Removal Final Work Plan* (Navy, 2010). Site conditions include descriptions of geology, hydrology, groundwater, threatened and endangered species, environmentally sensitive areas, wetlands and streams, adjacent land usage and current and future land use.

Geology

The geology at HPNS consists of Franciscan Formation bedrock; unconsolidated deposits of sand, gravel, and clays; and artificial fill. The artificial fill is present in approximately 400 acres that were reclaimed from the Bay (NAVSEA, 2000) and filled on a level plane about 12 to 15 feet above mean sea level.

In the late 1930s and early 1940s, fill was used to create the land surface beyond the historic shoreline at HPNS. This fill ranged from silty and sandy clays with gravel to poorly graded sands, boulders, and debris deposits. A majority of the coarse fill material was locally derived from the Franciscan Formation bedrock consisting of serpentinite, greenstone, shale, greywacke, and chert. Competency of the bedrock material encountered near the surface at Parcel E ranges from low to very hard, and fractures are common. The weathered material is decomposed and is friable. The unweathered Franciscan bedrock is hard and fractured. In general, samples collected from Franciscan-derived materials report low radiological readings. The bedrock material is often referred to as "serpentinite" by the HPNS field workers.

SAP Worksheet #10—Conceptual Site Model (continued)

Hydrology

HPNS straddles two of the seven San Francisco groundwater basins: the Islais Valley Groundwater Basin, which lies to the northeast, and the South Groundwater Basin, which lies to the southwest. The City and County of San Francisco supply the potable water used at HPNS. Groundwater from HPNS is not used for domestic purposes. There are no reports of operational water supply wells within 1 mile of HPNS. All wells at HPNS are groundwater monitoring wells.

Groundwater

An A-aquifer, a B-aquifer, and one bedrock water-bearing zone have been identified at HPNS. The A-aquifer is generally unconfined, consisting of artificial fill and Undifferentiated Upper Sand Deposits overlying Bay Mud, and is unconfined and shallow with depths to groundwater ranging from 2 to 17 feet below ground surface (bgs). Recharge is from precipitation infiltration, Bay water, and to a lesser extent leaks from water and storm drain lines.

Threatened and Endangered Species

Physical structures, such as riprap and docks, serve as artificial habitats for estuarine life. Marine life has been disturbed as a result of activities in the Bay adjacent to HPNS. Several hundred types of plants and animals, including the following, are believed to live at or near HPNS: terrestrial and marine plants and algae; benthic and water column-dwelling marine animals such as clams, mussels, amphipods, and fish; insects; amphibians; reptiles; birds; and mammals (Levine-Fricke Recon, Inc., and PRC Environmental Management, 1997). No federally listed endangered or threatened species are known to permanently reside at HPNS or the vicinity (Levine-Fricke Recon, Inc., and PRC Environmental Management, 1997); however, San Francisco Bay is a seasonal home to migrating fish and birds.

Environmentally Sensitive Areas

Environmentally sensitive areas are located on and in the vicinity of HPNS. Two types of wetland habitat, saline-emergent wetland (coastal salt marsh) and small seasonal freshwater wetland are found in the several small wetland areas along the undeveloped southern HPNS shoreline in Parcel E. These areas provide the greatest ecological diversity of any habitat at HPNS. Several small areas of saline-emergent wetland are located within the intertidal zone along the Bay shoreline edges. Plant species observed in these areas during a February 1997 field survey included pickleweed (Salicornia virginica), salt grass (Distichlis spicata), and cordgrass (spartina foliosa). A small freshwater emergent wetland area, supported by a small intermittent freshwater source, is located on approximately 1 acre in IR Site 01/21 (IR-01/21). Observed plant species in this wetland include the toad rush (Juncus sp.), umbrella sedge (Cyperus laevigatus), Pacific Coast bulrush (Scirpus robustus), and rabbit's-foot grass (Polypogon monspeliensis). Waterfowl, shorebirds, and wading birds may use wetland habitats as a source of food, cover, and water. The following animal species were observed at HPNS during the February 1997 field survey: the common snipe (Gallinago gallinago), greater yellowlegs (Tringa melanoleuca), killdeer (Charadrius vociferus), mallard (Anas platyrhynchos), great blue heron (Ardea herodias), and great egret (Casmerodius albus). The abundance of shorebirds may serve as prey for raptors, such as the endangered peregrine falcon (Falco peregrinus). Small animals, such as the raccoon (Procyon lotor), opossum (Didelphis virginiana) and the burrowing owl (Athene cunicularia), may forage in or along the edges of wetland habitat. Harbor seals (Phoca vitulina richardsi) are known to feed in the waters off HPNS.

SAP Worksheet #10—Conceptual Site Model (continued)

Wetlands and Streams

Two freshwater streams, Yosemite and Islais Creeks, flow into San Francisco Bay adjacent to the border with HPNS. Surface water resources at the site are limited to small groundwater seeps from exposed bedrock and the surface water in adjacent San Francisco Bay.

Adjacent Land Usage

Development of land surrounding the HPNS site during the past 60 years has consisted of light and heavy industrial facilities, other shipyards, commercial fishing operations, and some residential dwellings. The rapid growth of the shipyard and its support facilities during World War II fueled the buildup of housing and commercial enterprises in the immediate vicinity of HPNS to support the increased workforce at the yard. The San Francisco Housing Authority public housing, Hunters Point A-West, E-West, Hunters View, and Westbrook, are located in the immediate vicinity of HPNS. These communities form a large housing area, part of which is adjacent to the HPNS entrance gate. Other surrounding areas contain a mixture of light and heavy industries, including automobile recycling, repair shops, and food manufacturers. Retail ventures, including stores and restaurants, are also located within 1 mile of HPNS.

Current and Future Land Use

For over 20 years, the Navy has leased many HPNS buildings to private tenants and Navy-related entities for industrial and artistic uses, including storage space, art studios, machine workshops, woodworking shops, automobile restoration garages, recreational vehicle parking, and filming of movies.

Transport and Exposure Pathways

The 2006 AM identified several threats to public health, welfare and the environment:

- Nearby human populations may be affected by exposure to low-level radioactive materials.
- Low-level radioactive materials may migrate or be released because of their presence near the surface.
- Low-level radioactive materials may migrate or be released because of weather conditions.
- Nearby animals, and food chains may be affected by exposure to low-level radioactive materials.
- Radioactive materials can have very long half-lives. Their release into the environment could be detrimental.

The primary contaminant transport mechanisms for radionuclides at HPNS are (1) leaching from soil to groundwater by infiltrating precipitation or as a result of fluctuating groundwater levels, (2) discharge from groundwater to surface water through direct discharge or via leaking utility lines, (3) volatilization from soil or groundwater to soil gas and then indoor air, and (4) transport of soil or shoreline sediment to surface water with overland flow of storm water.

The purpose of this project is two-fold:

1. To perform a comprehensive assessment of a component (or subset) of the existing radiological data in order to determine its' validity to support decisions regarding transfer of property at HPNS; and,
2. To conduct confirmation survey sampling to confirm or corroborate data assessment findings and/or prior sampling results from previous radiological remediation activities. Soil confirmation samples will be collected from areas where questions or concerns remain regarding the possible misrepresentation of data during radiological remediation activities at HPNS. The soil confirmation sample data obtained will be used to determine whether additional action and/or samples are necessary to supplement prior sampling results.

Further investigation of other media, if required, will be scoped separately.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
State the Problem	**Identify the Goals of the Study**	**Identify Information Inputs**	**Define the Boundaries of the Study**	**Develop the Analytic Approach**	**Specify the Performance or Acceptance Criteria**	**Develop the Plan for Obtaining Data**
In 2012, during review of systematic radiological soil samples, the NAVSEA RASO found that the final systematic sample data submitted did not correspond to soil samples taken from the same site. This led to suspicion that the soil samples were collected from a location different from the one specified in the Final Status Survey Report. The contractor conducted an internal investigation to identify the source of the discrepancy and took corrective action. The results are presented in a report finalized in 2014. Since 2014, former workers have alleged other types of wrong doing that were conducted during the radiological cleanup and those allegations have been reported in the local media. Several agencies, including the Nuclear Regulatory Commission, were or are currently conducting investigations regarding the possible misrepresentation of data during radiological remediation activities at HPNS. As a result, USEPA and DTSC, the lead federal and state regulatory agencies overseeing HPNS cleanup work, have stated that they will not support the transfer of HPNS property to the City of San Francisco until they are more confident that remedial decisions made were based on factual data. Specifically, USEPA and DTSC directed in the letter that "the Navy will not propose any further transfers of Navy property at HPNS without results of these investigations and/or any other Navy action necessary to clarify the actual potential public exposure to radioactive material at and near the HPNS" USEPA and DTSC, 2016). The Navy is unable to transfer property until the radiological data collected by the Navy's contractor is evaluated and concluded to be valid, useable as is, or replaced with newly collected data.	• To evaluate and communicate the validity (or not) of the existing radiological data to see if it can be used to support decisions regarding transfer of property at HPNS. • To confirm or corroborate data evaluation findings and/or prior sampling results with additional samples if, after the evaluation process, the Navy believes additional data is necessary. • To compare radiological data obtained during the confirmation sampling to Derived Concentration Guideline Levels (DCGLs). • To compare radiological data obtained during the confirmation sampling to prior sampling results and recommend additional remediation if necessary. • To compare radiological data obtained during the confirmation sampling to background value references.	• Data evaluation and statistical analysis of available soil data collected by TtEC. • Background value references (multiple sources). • Soil analytical data collected during prior sampling events. • Soil analytical data from laboratory analysis of TtEC archived soil samples collected during prior sampling events but not previously analyzed. • DCGLs - release criteria for the project, as specified in the AM for Time Critical Removal Action Table 1, column containing "Soil Residential (pCi/g)" (Navy, 2006). • Visual observations from test-pitting and boring logs under the supervision of a California-licensed Professional Geologist and radiological health physicist. • Validated soil analytical data collected during this confirmation soil survey. • Radiological survey measurements in the field. • Input from regulatory agencies.	• Lateral boundaries for the soil confirmation survey are Parcels B, C, D-2, E, G, UC-1, UC-2, and UC-3 (shown on **Figure 10-2**). More specific lateral boundaries will be designated in the individual TSPs. • The vertical boundary for the soil confirmation survey will be the depth of previous excavation and depth of previous final status survey soil sample collection. Actual depths may vary based on field conditions. • Surface soil and subsurface soil are the media of interest for this soil confirmation survey. • The temporal boundary for the soil confirmation survey will be the time to completion of the confirmation survey report, assumed to be 2018.	If radiological data obtained during soil sampling are within the range of naturally-occurring radionuclide activity, and less than the DCGLs, then soil sampling will be deemed complete. It will be concluded that prior data that has not been manipulated are valid and usable for property transfer decisions. • If radiological data obtained during the soil sampling exceeds the DCGLs, and exceed the range of naturally-occurring radionuclide activity, then additional radiological sampling and data collection will be conducted to delineate the lateral and vertical extent of radionuclides and additional radiological cleanup may be recommended. It will be concluded that prior data that has not been manipulated may be used for property transfer decisions. • If radiological data obtained during the soil sampling exceed the DCGLs but are within the range of naturally-occurring radionuclide activity, then soil sampling will be deemed complete. It will be concluded that prior data that has not been manipulated may be used for property transfer decisions. • Data evaluation results will be summarized along with the results of the confirmation survey sampling, and used to provide recommendations on whether the existing data should be used to support property transfer decisions.	• Surface and subsurface confirmation soil sampling will be conducted using field sampling and processing methods as described in **Worksheet #14**, and specified in individual TSPs. Sample locations will be determined based on the data evaluation where findings suggest potential falsification of data has occurred. The sample locations will be specified in the TSPs. • For reproducibility and comparability of analytical data, standard USEPA-approved analytical methods will be used. Samples will be submitted to laboratories that are accredited by the Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) per the DoD Quality Systems Manual Version 5.1, the DOE Quality Systems for Analytical Services Version 3.1 and California ELAP. • Performance criteria for the soil collection and analysis are established based on the following DQIs: precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS). Sensitivity requirements are established by the PALs presented in **Worksheet #15**. Requirements for other DQIs are presented in **Worksheets #12**, **#28**, and **#37**.	Due to the potentially widespread nature of sampling locations, individual TSPs will be developed using this SAP as guidance. Prior to conducting field activities, a data evaluation will be conducted in two phases to evaluate radiological data and determine how to conduct confirmation sampling. The two phases consist of the following: • Phase 1 is underway to develop a soil database with available data, conduct soil data evaluation to identify anomalies indicating potential data falsification while validating sources of usable data, and identify data gaps for Phase 2 evaluation • Phase 2, will be conducted to further evaluate anomalous data identified during Phase 1 and to design and conduct confirmation sampling. Areas of previous remediation activities where confirmation samples may be collected include: • Sites with worker allegations (e.g., Building 351A Crawl Space) • Select anomalous areas identified by statistical testing for sampling The sampling plan for obtaining data will include a combination of one or more of these that will be specified in the TSP: • Collection of radiological field measurements (gamma walkover survey, general area dose rate measurement, soil core measurements, soil sample measurement). • Advancing direct-push borings for background or confirmation soil sample collection. Collect confirmation soil samples at biased or systematic locations. • Excavating test pits for background or confirmation soil sample collection. • Hand-augering at locations where the direct-push technology (DPT) rig and/or excavator cannot gain access for soil confirmation sample collection or background sampling. • Samples will be analyzed for key primary radionuclides Cs-137, Ra-226, Bi-214, Pb-214, K-40, Ac-228, Bi 212, and Pb-212. A subset of samples will also be analyzed for the secondary radionuclide Sr-90. Additional radionuclides may be analyzed on an as-needed basis and include Am-241, Co-60, Eu-152, Eu-154, Pu-238, and Pu-239. • The final analysis for all radionuclides will be determined based on site specific evidence that will be identified during the data evaluation. The analysis will be detailed in the TSPs and may also be determined post laboratory analysis. • Evaluation of analytical data to determine if additional data gaps exist.

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SAP Worksheet #12—Field Quality Control Samples - Soil

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Field Duplicate	Radiological (alpha and gamma spectroscopy, Gas Flow Proportional Counting)	One per every 10 field samples collected	Precision	RPD < 25%
Equipment Blank		One per day of field sampling for decontaminated equipment	Bias/Contamination	No target analytes detected > MDC
Field Blank		One per source water per sampling event.	Bias/Contamination	No target analytes detected > MDC
Split Sample[a]		One per every 20 field samples collected, or as requested	N/A	None

Notes:

[a] May be collected if requested by EPA or CDPH

MDC = minimum detectable concentration

RPD = relative percent difference

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SAP Worksheet #13—Secondary Data Criteria and Limitations

Secondary Data	Data Source (originating organization, report title, and date)	Data Generators (originating organization, data types, data generation / collection dates)	How Data Will be Used	Limitation on Data Use
Soil Data	TtEC *Multiple Plans, reports, and final status survey soil data* 2006-2016	TtEC, soil, various radionuclides of concern, 2006-2016	Data will be used in conjunction with new data to determine the adequacy, consistency, and validity of the prior (TtEC) survey data.	Limited data use based on potential for anomalous data due to misrepresentation
Soil Data	TtEC *Investigation Conclusion Anomalous Soil Samples* April 2014	TtEC, soil, Bi-214, Pb-214, Ra-226, and K-40, 2012	Data will be used in conjunction with new data to determine the adequacy, consistency, and validity of the prior (TtEC) survey data.	No limitations on validated data
Soil Data	TtEc Archived soil samples	TtEC, soil, archived samples from various years	Data will be used in conjunction with new data to determine the adequacy, consistency, and validity of the prior (TtEC) survey data.	No limitations on validated data
Background Radiological Data	To be provided in the TSPs	To be included in the TSPs	Historic background data will be used for DCGL calculation for Ra-226 in the TSP.	No limitations on validated data

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SAP Worksheet #14—Summary of Project Tasks

This SAP will be included as **Attachment 3** of the HPNS Radiological Work Plan which will contain detailed information on the radiological support activities that will be conducted alongside the soil sampling activities outlined in this SAP. All radiological support work will be performed in accordance with the attendant radiological SOPs which will be included as **Attachment 4** of the Radiological Work Plan.

This worksheet contains detailed procedures for field activities. Field SOPs specific to the soil sampling discussed in this SAP are presented in **Worksheet #21**.

Task Specific Plans

This SAP will provide guidance on sampling, analysis, and QA for specific sampling activities pertaining to the soil confirmation survey at HPNS. This SAP will be used as a reference document by all field and laboratory personnel engaged in the soil sampling and analysis activities for the soil confirmation survey sampling activities. The SAP is an attachment to the Radiological Work Plan that contains additional information needed to execute the fieldwork using this SAP as guidance. TSPs will be developed for each site or area that will be addressed as part of the soil confirmation survey. Each TSP will be provided to the Navy RPM and Navy QAO for review and approval prior to implementation and will include the following information as applicable to the task:

- Task description, including the specific location history, purpose of the task, and the radionuclides of concern
- Site-specific sample locations, sample depths, number of samples, and specific sample analysis
- DQOs defined to a level sufficient to ensure that the data obtained will support the goals of the task
- An activities plan consisting of a soil sample confirmation description and discussion of additional activities necessary to support the soil sampling
- Specific identification of variations, if any, to the Plan, including the work plan requirement, the required variations, and the technical justification for the variations
- Specific survey figures (as required) that provide sampling locations and other figures necessary to support the activity
- Attachments (as necessary) to provide further description, information or delineation of the task activities

Preparatory Activities

A project kickoff meeting will be held prior to mobilization to begin fieldwork. The Navy RPM, RASO, DTSC, USEPA, Resident Officer in Charge of Construction (ROICC), Caretaker Site Office (CSO), and Base security personnel will be notified regarding the anticipated fieldwork and schedule. A field kickoff meeting will be conducted and will include (but may not be limited to), CH2M PM, Field Team Leader, Subcontractor Leads, and SSHO. The primary discussion points for the meeting will include scope of work, schedule, logistics, field coordination issues, and safe access to the site. The appropriate subcontractors will be procured for vegetation clearance, utility locating, DPT drilling, test-pitting, laboratory analysis, and data validation as needed.

Prior to conducting field activities, field personnel will review the applicable sections of the SAP, schedule, APP and SSHP, and will sign the Project Personnel Sign-off Sheet (**Worksheet #4**). Field personnel will also refer to the individual TSPs for each site for task specific preparatory activities.

Safety considerations for proposed field tasks are discussed in the project-specific SSHP (submitted under separate cover).

SAP Worksheet #14—Summary of Project Tasks (continued)

Field Logbook

Field notes will be kept in bound, weatherproof logbooks. Notes will be taken with waterproof, nonerasable ink. Field staff completing separate tasks will keep separate logbooks, as necessary, according to the following protocol:

- Company name, address, author, activity, location, project name, PM, and emergency contact information will be included on the inside cover of the logbook.
- All lines of all pages will be used. Any line not used will be marked through with a line and initialed and dated. Pages not used will be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
- If errors are made in the logbook, a single line will be crossed through the error and the correct information entered. All corrections will be initialed and dated by the personnel performing the correction.
- Daily entries will be made chronologically and will be recorded directly in the field logbook during the work activity.
- Each page of the logbook will have the date of the work and the note taker's initials.
- The final page of each day's notes will include the note taker's signature, printed name, and the date.
- Only information relevant to the subject project will be added to the logbook.
- Entries into the logbook will be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory.
- Entries must be legible and complete.
- The field notes will be copied/scanned/photographed and the sent to the PM daily, unless otherwise approved.

The following general information will be recorded in the field logbooks:

- The general scope of work to be performed each day
- The weather conditions and any significant changes in the weather during the day
- Summary of tailgate health and safety meetings or other meetings onsite
- Personnel in attendance
- Equipment used onsite
- Level of personal protective equipment and instruments being used
- Field analyses performed, including results, instrument checks, problems, and calibration records for field instruments (if applicable)
- A detailed, chronological account of activities each day
- Complete names, arrival times, departure times, roles, and affiliations of all personnel who enter the site; acronyms may be used after established in the logbook

SAP Worksheet #14—Summary of Project Tasks (continued)

- Communications (visitors, phone, subcontractors, field staff) that may affect performance of the project
- Deviations from the work plan and the reason deviations were required (deviations must be approved in advance using a field change notice)
- Health and safety incidents
- Quantities of consumable equipment used, if it is to be billed to the project
- Problems encountered during the fieldwork and the corrective actions taken to address these problems
- Any conditions that may adversely affect the work or data obtained
- Sampling performed, including specifics such as location, type of sample, type of analyses, and sample identification sample dates, and times
- QC activities

Additional requirements for field logbooks are included in the Radiological Work Plan or TSPs.

Field Activities

Vegetation Clearance

It is anticipated that light vegetation clearance may be required across certain areas of the site prior to conducting confirmation sampling. Prior to mobilizing, the Field Team Leader will walk the site to determine the visible extent of vegetation. Vegetation will be trimmed back (as minimally as possible) within the area where soil confirmation sampling will be conducted, in order to increase safety and efficiency for site observation and access during sampling activities. Care will be taken to leave root systems in place in order to maintain soil stabilization. Trimmed vegetation will be placed in roll-offs and disposed of offsite as green waste.

Utility Clearance

Utilities will be identified and flagged prior to the performance of any intrusive activity. CH2M will coordinate utility clearance with the base's approving authority and notify Underground Service Alert at least 5 full working days in advance of any subsurface sampling activity and. Known underground utilities will be clearly marked using a system of pin flags positioned on the ground surface, above the underground utility location. Additionally, a separate private utilities subcontractor will be procured to ensure the accuracy of the utility markings. Any proposed soil confirmation sampling locations interfering with utility locations will be relocated to avoid impact to utilities while continuing to meet the intent of the sampling rationale.

Land Surveyor

Depending on the work being done, soil sample locations will be surveyed using a combination of GPS and professional land surveying. Upon completion of confirmation survey, a professional surveying crew will be mobilized to the site to map soil sample locations where feasible. The sample locations will be mapped using the 1983 North American Datum State Plane Coordinate System, California, Zone 3. Elevation data will be recorded as above mean sea level.

SAP Worksheet #14—Summary of Project Tasks (continued)

Test-pitting

Test-pitting will be conducted to identify lithology and collect soil samples to determine whether radionuclide concentrations exceed DCGLs and to assess the results of previous sampling activities. The number, location, and depth of test pits and soil samples as well as sample analysis will be specified in each individual TSP. Radiological measurements in the field are included in the Work Plan and TSPs. Test pits will be excavated using a backhoe and soil confirmation samples collected. Samples will be collected as specified in the TSP on the walls or bottom of the test pit. Soil samples will be collected as described in the soil sample collection section below.

The materials removed from the test pits will be placed on plastic sheeting approximately 5 feet away from the edge of the pit to avoid caving. Each bucket of material removed from the pit will be visually observed by the field geologist under the supervision of a California-licensed Professional Geologist and radiological health physicist, and a test pit log (**Attachment 2**) will be maintained. The test pit log will include a description of the depth and physical nature of the fill/soil encountered. Fill/soil will be described in accordance with the American Society for Testing and Materials (ASTM) Method D 2488, (Visual-Manual Procedures) *Standard Practice for Description and Identification of Soils*. Soil color will be based on the Munsell Color System.

Geo-referenced photographs of pit conditions will be taken, as necessary, to document the nature of the material and changing conditions or lithology. When a test pit is complete, it will be backfilled with the original material and compacted using a vibratory plate attachment or equivalent method.

Direct-push Drilling

In accordance with ASTM Method D6282, *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*, a track-mounted, DPT drill rig will be used to advance soil borings to approximately 10 feet bgs in select anomalous areas. Prior to drilling, a hand auger will be used to advance the borehole to 6 feet in order to ensure utility clearance. The number, location, and depth of boreholes per area will be specified in each individual TSP. Downhole equipment will be decontaminated before use at each location consistent with the procedures discussed in the Field Equipment Decontamination subsection of this worksheet. Borings will extend to the depth specified in the TSP or until refusal is encountered. An attempt will be made to collect continuous core samples in acetate liners; however, refusal may dictate that discrete sampling be conducted. Soil samples will be visually observed by the field geologist with observations recorded on a boring log (**Attachment 3**) for each boring. The boring log will include a description of the fill/soil encountered. Fill/soil will be described consistent with the ASTM Method D 2488, *Standard Practice for Description and Identification of Soils* (Visual-Manual Procedures). Fill/soil color will be based on the Munsell Color System. Soil samples will be collected as described in the soil sample collection section below. Radiological measurements in the field are included in the Work Plan and TSPs.

Hand Augering

Hand augering will be performed at locations where the DPT rig and/or excavator cannot gain access for soil confirmation sample collection. At these locations, a hand auger will be used to collect surface soil samples (0 to 0.5 foot bgs). A hand auger may also be used to collect subsurface soil samples on slopes that are not accessible with mechanized equipment, as determined by the field geologist. An attempt will be made to advance the hand auger for sample collection to a depth of no more than 10 feet bgs. However, refusal may limit sampling deeper intervals.

SAP Worksheet #14—Summary of Project Tasks (continued)

The hand auger will be decontaminated prior to each sample interval consistent with the procedures discussed in the Field Equipment Decontamination section of this worksheet below. Cuttings will be visually observed by the field Geologist with observations recorded on a boring log (**Attachment 3**) for each hand auger boring. The boring log will include a description of the physical nature of the fill/soil encountered. Fill/soil material will be described consistent with the ASTM Method D 2488, *Standard Practice for Description and Identification of Soils* (Visual-Manual Procedures). Soil/fill color will be based on the Munsell Color System. Soil samples will be collected as described in the soil sample collection section below. Radiological measurements in the field are included in the **Radiological Management Plan, Attachment 2** of the Radiological Work Plan and TSPs.

Soil Sample Collection

Soil samples will be collected and submitted for laboratory analysis of radionuclides to be specified in each individual TSP. The number, location and depth of soil samples will also be specified in the individual TSPs for each area of investigation. Soil samples may be split with stakeholders including the Navy, DTSC, and the USEPA and submitted for independent third party laboratory analysis.

For DPT sample collection, upon extracting the sampler, the acetate liners will be removed, and the section from the appropriate depth range will be sealed with Teflon-lined plastic caps. The fill/soil will be emptied into a stainless steel mixing bowl for homogenization, then placed into jars supplied by the analytical laboratory. The samples will be labeled, placed in a plastic bag, and stored in a cooler for submittal to the analytical laboratory. The fill/soil in the remaining acetate liners will be used for observation and lithology description.

For test pit and hand auger sample collection, the fill/soil will be collected from the specified depth and emptied into a stainless steel mixing bowl for homogenization, then placed into jars supplied by the analytical laboratory. The samples will be labeled, placed in a plastic bag, and stored in a cooler for submittal to the analytical laboratory. The fill/soil at the sampling depth will be observed and the lithologic description logged.

Soil samples will be handled consistent with chain-of-custody protocols discussed in **Worksheet #27**. Waterproof labels will be attached to each sample container. Samples will be placed in Ziploc-brand freezer bags and placed in a cooler with ice. The chain-of-custody documentation will be completed as samples are collected. At the end of the day, chain-of-custody documentation will be verified with samples in the cooler and noted in the field logbook. Each day, samples will be relinquished to a courier provided by the analytical laboratory, according to chain-of-custody protocol as described in **Worksheet #27**.

Borehole and Test Pit Completions

DPT and hand auger borings will be backfilled using hydrated bentonite pellets. The bentonite pellets will be hydrated with potable water from a bucket. Care will be taken to add the water and materials slowly, to avoid bridging or collapse. The test pits will be backfilled with the original excavated soil material and completed at the surface with concrete or asphalt to match existing conditions.

Field Equipment Decontamination

The drilling subcontractor will decontaminate downhole equipment before the onset of drilling, between boring locations, and before leaving each site using a three-step process or a high-pressure steam cleaning with containment. The DPT sampler and hand auger will be decontaminated between sample intervals at each location, using the following three-step process:

1. Rinse with tap water and Liquinox (or comparable) solution
2. Rinse with tap water
3. Rinse with distilled water

SAP Worksheet #14—Summary of Project Tasks (continued)

The backhoe subcontractor may use a combination of the three-step process and steam cleaning. Decontamination water will be contained in 55-gallon drums and stored in a location designated by the Navy. If differences exist between decontamination procedures in the SAP and SOPs, then the SOP will be considered primary.

Following decontamination, all equipment in contact with soil will be radiologically released in accordance with the radiological subcontractors SOPs provided in **Attachment 4** of the separate Radiological Work Plan.

Management of Investigation Derived Waste (IDW)

Investigation derived waste (IDW) generated during this confirmation survey include, but may not be limited to, soil brought to the surface during sampling with the hand auger or geoprobe and PPE. IDW will be categorized as either low-level radioactive waste (LLRW) or low-level mixed waste (LLMW).

Auger or geoprobe soil cuttings will be placed in a 55-gallon drum. When the drum is full it will be sampled for the HPNS radionuclides of concern and chemical contaminants, if warranted given the specific locations sampled and the potential for hazardous chemicals. Chemical analyses, when required, will be performed using Toxicity characteristic leaching procedure (TCLP) and the specific analytic suites will be specified in the TSP. PPE will be scanned and disposed of appropriately.

Each 55-gallon drum containing LLRW or LLMW will be labeled accordingly. Following labeling, the waste container will be placed in a designated and posted radiologically controlled material storage area. CH2M and subcontractors working on this project will coordinate with the Navy to determine an appropriate site location to store IDW.

Soil and PPE intended for off-site disposal will be transported to a CERCLA Off-site, Rule approved waste facility for treatment and/or disposal. Use of any disposal facility for LLRW and LLMW is subject to approval by the DoD LLRW Executive Agency (Army).

Additional IDW management procedures are outlined in the Remedial Management work plan (RMP) (**Attachment 2, Radiological Work Plan**).

QA/QC

A Senior QA/QC manager with knowledge of radiological QA/QC will be present in the field for the duration of soil confirmation sampling activities. The QA/QC manager's sole responsibility will be to ensure that the quality control measures in the project plans are performed. The QA/QC manager shall maintain all QA/QC records for review and provide copies in the final report.

Analytical Data Validation and Evaluation

Analytical data validation will be conducted by an independent third-party data validation subcontractor in accordance with Worksheets 34- 36 and is consistent with Navy Environmental Work Instruction (EWI) No. 1, *Data Validation Guidelines for Chemical Analysis of Environmental Samples* (Navy, 2001), *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP) (USEPA; 2004), and *USEPA National Functional Guidelines for Inorganic Superfund Data Review* (ISM02.2) (USEPA, 2016b) may also be applicable. Of the analytical data, 100 percent will be validated by a third-party data validation subcontractor, with 20 percent Stage 4 validation and 80 percent Stage 2B validation.

SAP Worksheet #14—Summary of Project Tasks (continued)

Stage 4 data validation follows the USEPA protocols and criteria set forth in the functional guidelines for, inorganic, and radiological data review (USEPA, 2004, 2016b). These guidelines apply to analytical data packages that include the raw data (for example, spectra and chromatograms) and backup documentation for calibration standards, analysis run logs, laboratory control samples (LCSs), dilution factors, and other types of information. This additional information is used in the Stage 4 data validation process for checking calculations of quantified analytical data. Calculations are checked for QC samples (for example, matrix spike [MS]/matrix spike duplicate [MSD] and LCS data) and routine field samples (including field duplicates, field and equipment rinsate blanks,). To ensure that detection limit and data values are appropriate, an evaluation is made of instrument performance, method of calibration, and the original data for calibration standards.

Under the Stage 2B data validation effort, the data values for primary and QC samples are generally assumed to be correctly reported by the laboratory. Data quality is assessed by comparing the QC parameters listed in the previous paragraph to the appropriate criteria (or limits) as specified in this SAP, by Contract Laboratory Program (CLP) requirements, or by method-specific requirements (for example, CLP, SW-846). If calculations for quantitation are verified, it is done on a limited basis and may require raw data in addition to the standard data forms normally present in a data package.

Data Management

Data management will begin upon collection of field measurements, which will be recorded in the site-specific field logbook and retained in the project files, to the final submittal of the analytical data that is checked for accuracy through the validation process. Throughout the data life cycle, the project team and project subcontractors (for example, laboratory and data validation) will be responsible for performing data verification so that the data are complete, correct, and compliant with project objectives and contractual requirements.

Analytical data will be provided by the analytical laboratory in the hard copy and electronic, CH2M-required formats. If the electronic data have successfully passed the data checker, the laboratory will provide the analytical data in the contractually required EDD format, which will then be loaded to the CH2M data management system for further verification and validation. The data will not be released to the project team or Navy until the data are final with data validation qualifiers applied. Once the data are deemed final and complete, the data will be prepared in the required Naval EDD format and uploaded to NIRIS, consistent with the Navy EWI No. 6, *Environmental Data Management and Required Electronic Delivery Standards* (Navy, 2005).

NIRIS deliverables are submitted using the NEDD Data Checker which is located on the NIRIS Portal. The Data Checker runs checks on NEDD deliverables, ensures key business rules are adhered to, and checks submittals against NIRIS central data base. When the “Submit” button is clicked, the NEDD submittal is automatically transferred to the NIRIS RDM and an e-mail is sent to the contacts listed on the submittal form. This e-mail will include a tracking number that can be used to check the status of the data as it moves through the loading process. The NIRIS RDM will send an e-mail with a successful load response, questions or rejection status within 10 days. Data have not been successfully loaded to NIRIS until a successful load response has been received. Additional instructions for this process are available in the NEDD SOP which is located on the NIRIS Portal.

Confirmation Survey Report

The confirmation survey report will document activities and findings of the confirmation soil survey. Preparation of the confirmation survey report will include data reduction, tabulation and analysis, report preparation, QC checks, and responses to comments (RTCs) from regulatory stakeholders. The report will include a description of field activities, analytical results and analysis, updated conceptual site model(s) if needed, and confirmation sampling results as one of multiple lines of evidence to support decisions for property transfer.

SAP Worksheet #14—Summary of Project Tasks (continued)

Radiological data obtained during the confirmation sampling will be compared to DCGLs to determine if radionuclide concentrations exceed DCGLs. The DCGLs for this confirmation survey, are the release criteria for the project as specified in the AM for Time Critical Removal Action Table 1, column containing "Soil Residential (pCi/g)" (Navy, 2006).

Attachments to the draft and final confirmation survey report will include test pit logs, boring logs, analytical data, analytical data validation reports, and other supporting data from previous activities. The report will be submitted as preliminary draft, draft, and final versions. The Navy will be provided with each version for review and comment, and documents will be reviewed and approved by the Navy prior to submittal to regulatory agencies. RTC matrices will be prepared for each comment set received. The RTCs will be used at each review step to facilitate approval of comment responses.

SAP Worksheet #15a—Reference Limits and Evaluation Soil Gamma Spectroscopy

Matrix: Soil

Analytical Group: Radiological (gamma spectroscopy) – USEPA Method 901.1

Analyte	CAS	Project Screening Limit (pCi/g)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/g)	Laboratory-Specific Limits[c,d,e]
					MDC (pCi/g)
Cesium-137	10045-97-3	0.113	AM	0.05	0.05
Radium -226	13982-63-3	1.0 above background[f]	AM	0.1	0.1
Bismuth-214	14913-49-6	none	--	0.1	0.1
Lead-214	--	none	--	0.1	0.1
Potassium-40	--	none	--	0.5	0.5
Actinium-228	--	none	--	0.3	0.3
Bismuth-212	--	none	--	1.0	1.0
Lead-212	--	none	--	0.1	0.1
Americium-241	--	1.36	AM	0.3	0.3
Cobalt-60	--	0.0361	AM	0.05	0.05
Europium-152	--	0.13	AM	0.1	0.1
Europium-154	--	0.23	AM	0.1	0.1
Protactinium-234	--	none	--	0.75	0.75
Lead-210	--	none	--	3.0	3.0
Thorium-232	--	none	--	0.1	0.1

SAP Worksheet #15a—Reference Limits and Evaluation Soil Gamma Spectroscopy (continued)

Matrix: Soil

Analytical Group: Radiological (gamma spectroscopy) – USEPA Method 901.1

Analyte	CAS	Project Screening Limit (pCi/g)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/g)	Laboratory-Specific Limits[c,d,e]
					MDC (pCi/g)
Thorium-234	--	none	--	2.0	2.0
Thallium-208	--	none	--	0.1	0.1

Notes:

[a] The PSLs are those provided in the HPNS Final Base-wide Removal Action Memo, Action Memorandum (AM), (Navy, 2006).

[b] Project QL goals are equal to the MDC.

[c] Results for non-aqueous samples are reported on a dry-weight basis.

[d] The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95% probability of detection, give a detection criterion that ensures on a 5 % probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC SW RPM and QAO in advance of sample testing.

[e] An MDC at or less than the value listed must be achieved for cesium-137 and radium-226 for all samples for this project. MDCs for other radionuclides analyzed by gamma spectroscopy are not required to be achieved unless specifically requested on the applicable COC.

[f] Radium-226 background for definitive data is 0.625 pCi/g for this SAP.

CAS = Chemical Abstracts Service

MDC = minimum detectable concentration

pCi/g = picocuries per gram

QL = Quantitation Limit

SAP Worksheet #15b—Reference Limits and Evaluation Soil Alpha Spectroscopy

Matrix: Soil

Analytical Group: Radiological (alpha spectroscopy) – USDOE Method HASL-300 A-01-R

Analyte	CAS	Project Screening Limit (pCi/g)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/g)	Laboratory-Specific Limits[c, d]
					MDC (pCi/g)
Plutonium-238	13981-16-3	none	AM	0.5	0.5
Plutonium-239/240[e]	15117-48-3	2.59	AM	0.5	0.5
Uranium-235/236[f]	15117-96-1	0.195	AM	0.5	0.5

Notes:

[a] The PSLs are those provided in the HPNS Final Base-wide Removal Action Memo, Action Memorandum (AM), 2006.

[b] Project QL goals are equal to the MDC.

[c] Results for non-aqueous samples are reported on a dry-weight basis.

[d] The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95% probability of detection, give a detection criterion that ensures on a 5 % probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC SW RPM and QAO in advance of sample testing.

[e] Plutonium-239 is listed in the above table as plutonium-239/240 because the alpha energy peaks for the isotope of plutonium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table.

[f] Uranium-235 is listed in the above table as Uranium-235/236 because the alpha energy peaks for the isotope of plutonium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table.

CAS = Chemical Abstracts Service

MDC = minimum detectable concentration

pCi/g = picocuries per gram

QL = Quantitation Limit

SAP Worksheet #15c—Reference Limits and Evaluation Soil Gas Flow Proportional Counting

Matrix: Soil

Analytical Group: Radiological (Gas Flow Proportional Counting) – USEPA Method 905.0

Analyte	CAS	Project Screening Limit (pCi/g)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/g)	Laboratory-Specific Limits[c,d]
					MDC (pCi/g)
Strontium-90	10098-97-2	0.331	AM	0.15	0.15
Total Strontium	7440-24-6	0.331	AM	0.15	0.15

Notes:

[a] The PSLs are those in the HPNS Final Base-wide Removal Action Memo, Action Memorandum (AM), (Navy, 2006).

[b] Project QL goals are equal to the MDC.

[c] Results for non-aqueous samples are reported on a dry-weight basis.

[d] The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95% probability of detection, give a detection criterion that ensures on a 5 % probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC SW RPM and QAO in advance of sample testing.

CAS = Chemical Abstracts Service

MDC = minimum detectable concentration

NA = not applicable

pCi/g = picocuries per gram

QL = Quantitation Limit

SAP Worksheet #15d—Reference Limits and Evaluation Water Gamma Spectroscopy

Matrix: Water (for field blanks only)

Analytical Group: Radiological (gamma spectroscopy) – USEPA Method 901.1

Analyte	CAS	Project Screening Limit (pCi/L)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/L)	Laboratory-Specific Limits[c,d]
					MDC (pCi/L)
Cesium-137	10045-97-3	none	--	15	15
Radium -226	13982-63-3	none	--	75	75
Bismuth-214	14913-49-6	none	--	75	75
Lead-214	--	none	--	75	75
Potassium-40	--	none	--	150	150
Actinium-228	--	none	--	150	150
Bismuth-212	--	none	--	300	300
Lead-212	--	none	--	30	30
Americium-241	--	none	--	75	75
Cobalt-60	--	none	--	30	30
Europium-152	--	none	--	120	120
Europium-154	--	none	--	150	150
Protactinium-234	--	none	--	150	150
Lead-210	--	none	--	450	450
Thorium-232	--	none	--	450	450

SAP Worksheet #15d—Reference Limits and Evaluation Water Gamma Spectroscopy (continued)

Matrix: Water (for field blanks only)

Analytical Group: Radiological (gamma spectroscopy) – USEPA Method 901.1

Analyte	CAS	Project Screening Limit (pCi/L)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/L)	Laboratory-Specific Limits[c,d]
					MDC (pCi/L)
Thorium-234	--	none	--	450	450
Thallium-208	--	none	--	15	15

Notes:

[a] The PSLs are not applicable for this matrix (i.e. field blanks)

[b] Project QL goals are equal to the MDC.

[c] The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95% probability of detection, give a detection criterion that ensures on a 5 % probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC SW RPM and QAO in advance of sample testing.

[d] An MDC at or less than the value listed must be achieved for cesium-137 and radium-226 for all samples for this project. MDCs for other radionuclides analyzed by gamma spectroscopy are not required to be achieved unless specifically requested on the applicable COC.

CAS = Chemical Abstracts Service

MDC = minimum detectable concentration

pCi/L = picocuries per liter

QL = Quantitation Limit

SAP Worksheet #15e—Reference Limits and Evaluation Water Alpha Spectroscopy

Matrix: Water (for field blanks only)

Analytical Group: Radiological (alpha spectroscopy) – USDOE Method HASL-300 A-01-R

Analyte	CAS	Project Screening Limit (pCi/L)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/L)	Laboratory-Specific Limits[c]
					MDC (pCi/L)
Plutonium-238	13981-16-3	none	--	1.0	1.0
Plutonium-239/240[d]	15117-48-3	none	--	1.0	1.0
Uranium-235/236[e]	15117-96-1	none	--	1.0	1.0

Notes:

[a] The PSLs are not applicable for this matrix (i.e. field blanks).

[b] Project QL goals are equal to the MDC.

[c] The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95% probability of detection, give a detection criterion that ensures on a 5 % probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC SW RPM and QAO in advance of sample testing.

[d] Plutonium-239 is listed in the above table as plutonium-239/240 because the alpha energy peaks for the isotope of plutonium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table.

[e] Uranium-235 is listed in the above table as uranium-235/236 because the alpha energy peaks for the isotope of plutonium cannot be separated in alpha spectroscopy. Therefore, the laboratory will report as listed above in the table

CAS = Chemical Abstracts Service

MDC = minimum detectable concentration

pCi/L = picocuries per liter

QL = Quantitation Limit

SAP Worksheet #15f—Reference Limits and Evaluation Water Gas Flow Proportional Counting

Matrix: Water (for field blanks only)

Analytical Group: Radiological (Gas Flow Proportional Counting) – USEPA Method 905.0

Analyte	CAS	Project Screening Limit (pCi/L)	Project Screening Limit Reference[a]	Project QL Goal[b] (pCi/L)	Laboratory-Specific Limits[c]
					MDC (pCi/L)
Strontium-90	10098-97-2	none	--	2.0	2.0
Total Strontium	7440-24-6	none	--	2.0	2.0

Notes:

[a] The PSLs are not applicable for this matrix (i.e. field blanks).

[b] Project QL goals are equal to the MDC.

[c] The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95% probability of detection, give a detection criterion that ensures on a 5 % probability of detection in an analyte-free sample. MDCs may vary from sample to sample depending on the composition of the sample matrix. Any changes to these limits which impact the project SAP objectives, must be approved by the NAVFAC SW RPM and QAO in advance of sample testing.

CAS = Chemical Abstracts Service

MDC = minimum detectable concentration

pCi/L = picocuries per liter

QL = Quantitation Limit

SAP Worksheet #16—Project Schedule/Timeline

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date of Initiation	Anticipated Date of Completion		
SAP	Navy BRAC and RASO	February 2017	June 2017	Final Work Plan with SAP	June 2017
SAP	Regulatory Agencies (DTSC, USEPA, Water Board)	June 2017	July 2017	Final Work Plan with SAP	July 2017
TSPs	Navy BRAC and RASO, Regulatory Agencies (DTSC, USEPA, Water Board)	June 2017	September 2017	Final Task Specific Plans	September 2017
Field sampling	CH2M/Cabrera Services/Permafix	July 2017	October 2017	None	None
Analytical Laboratory	GEL	October 2017	December 2017	Data reports (hard copy and EDD) by sample delivery group (SDG)	December 2017
Analytical data verification and validation	TBD	December 2017	January 2018	100 percent reviewed analytical data validation reports (hard copy and validated EDD)	January 2018
Confirmation Survey Report	Navy BRAC and RASO	January 2018	April 2018	Final Confirmation Study Report	April 2018
Confirmation Survey Report	Regulatory Agencies (DTSC, USEPA, Water Board)	March 2018	April 2018	Final Confirmation Study Report	April 2018

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SAP Worksheet #17—Sampling Design and Rationale

A soil confirmation survey will be performed to collect the data necessary to evaluate and communicate the validity (or not) of the existing radiological data to see if it can be used to support decisions regarding transfer of property at HPNS.

The sampling design and rationale will be site specific and will be outlined in the respective TSP for each site. Figures will be created for each TSP, showing the exact number, location, and depth of soil borings and test pits. The proposed confirmation survey sampling and analytical program as well as the potential rationale for selecting sample locations is discussed in **Worksheet #11**.

Sample results will be compared to the release criteria (DCGLs) that have been established for the site in the AM (Navy, 2006) (**Table 17-1**).

SAP Worksheet #17 – Sampling Design and Rationale (continued)

Table 17-1. Release Criteria

Radionuclide	Surfaces			Soil[d] (pCi/g)				Water[h] (pCi/L)
	Equipment, Waste (dpm/100 cm^2)[a]	Structures (dpm/100 cm^2)[b]	Residual Dose (mrem/yr)[c]	Outdoor Worker (pCi/g)[e]	Residual Dose (mrem/yr)[c]	Residential (pCi/g)[e]	Residual Dose (mrem/yr)[c]	
Americium-241	100	100	18.7	5.67	0.8661	1.36	24.84	15
Cesium-137	5,000	5,000	1.72	0.113	0.2142	0.113	0.2561	119
Cobalt-60	5,000	5,000	6.01	0.0602	0.5164	0.0361	0.3918	100
Europium-152	5,000	5,000	3.21	0.13[f]	0.5018	0.13[f]	0.502	60
Europium-154	5,000	5,000	3.49	0.23[f]	0.9593	0.23[f]	0.9599	200
Plutonium-239	100	100	18.1	14.0	1.743	2.59	1.138	15
Radium-226	100	100	0.612	1.0[g]	6.342	1.0[g]	14.59	5[i]
Strontium-90	1,000	1,000	0.685	10.8	0.1931	0.331	1.648	8
Thorium-232	1,000	36.5	24.9	2.7	24.91	1.69	25	15
Tritium	5,000	5,000	0.00053	4.23	0.00179	2.28	0.05263	20,000
Uranium-235+D	5,000	488	25	0.398	0.178	0.195	0.8453	30

Notes:

[a] These limits are based on AEC *Regulatory Guide 1.86* (1974). Limits for removable surface activity are 20 percent of these values.
[b] These limits are based on 25 mrem/yr, using RESRAD-Build Version 3.3 or *Regulatory Guide 1.86*, whichever is lower.
[c] The resulting dose is based on modeling using RESRAD-Build Version 3.3 or RESRAD Version 6.3, with radon pathways turned off.
[d] EPA PRGs for two future-use scenarios.
[e] The on-site and off-site laboratory will ensure that the MDA meets the listed release criteria by increasing sample size or counting time as necessary. The MDA is defined as the lowest net response level, in counts, that can be seen with a fixed level of certainty, customarily 95 percent. The MDA is calculated per sample by considering background counts, amount of sample used, and counting time.

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Page 2 of 2

[f] Based on EPA-decay corrected PRGs for commercial reuse and a previous action memorandum (TtEMI, 2000a, 2001).
[g] Limit is 1 pCi/g above background, per agreement with EPA.
[h] Release criteria for water have been derived from *Radionuclides Notice of Data Availability Technical Document*, (EPA, 2000) by comparing the limits from two criteria and using the most conservative limit.
[i] Limit is for total radium concentration.

AEC – Atomic Energy Commission
cm^2 – square centimeters
dpm – disintegrations per minute
EPA – U.S. Environmental Protection Agency
MDA – minimum detectable activity
mrem/yr – millirem per year
pCi/g – picocurie per gram
pCi/L – picocurie per liter
PRG – preliminary remediation goal
TtEMI – Tetra Tech EM, Inc.

SAP Worksheet #18—Location-Specific Sampling Methods/SOP Requirements

Sampling Location/ ID Number[a]	Matrix	Depth (feet bgs)[b]	Analytical Group	Number of Samples (identify field duplicates)	Sampling SOP Reference
HPPUC1-SS01/ HPPUC1-SS01-0001	Soil	0 – 0.5	Radiological (gamma spec); Radiological (alpha spec); Radiological (GFPC)	TBD	See **Worksheet #21**
HPPUC1-SB01/ HPPUC1-SB01-0102	Soil	1 - 2	Radiological (gamma spec); Radiological (alpha spec); Radiological (GFPC)	TBD	See **Worksheet #21**
HPPUC1-SB01/ HPPUC1-SB01P-0102	Soil	1-2	Radiological (gamma spec); Radiological (alpha spec); Radiological (GFPC)	Field Duplicate	See **Worksheet #21**
Field QC/HPPUC1-EB01-DD/MM/YYYY	Water	NA	Radiological (gamma spec); Radiological (alpha spec); Radiological (GFPC)	See below	See **Worksheet #21**

Notes:

[a] Example sample IDs for sampling have been provided. The site IDs, locations and number of samples collected per site/location will be defined in task specific sampling plans. Sample identification (ID) instructions are as follows: Sample IDs will use the following format – AABBBB-CCXX-XXYY where AA = facility; BBBB = site location; CC = sample type; XX = numerical sample number; XXYY = two-digit sample depth (from/to). For equipment blanks the following format – AABBBB-CCXX-XXYY where AA = facility; BBBB = site location; CC = sample type; XX = numerical sample number; DD/MM/YYYY = two-digit day/month and 4 digit year.

[b] Example depths have been provided for corresponding sample ID. Depths of samples and ID will be provided in TSPs.

Field QC counts are dependent upon the duration of the field event. Frequency of QA/QC collection is as follows:

- Field Blank - One per water source for each sampling event
- Equipment Blank - For decontaminated equipment, one per type of sampling equipment, per site location; for disposable equipment, one per lot.
- Field duplicates are collected at a frequency of 1 per 10 samples per matrix sent to the laboratory.
- Additional information on sample IDs is presented in **Worksheet #27**

EB = equipment blank

HP = Hunters Point

PUC1 = Parcel Unit 1

SB = subsurface soil

SS = surface soil

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SAP Worksheet #19—Field Sampling Requirements

Matrix	Analytical Group	Analytical and Preparation Method/ SOP Reference	Container[a] (number, size, and type)	Sample volume (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time
Soil	Radiological (gamma spectroscopy)	USEPA 901.1/ ST-RD-0102	Gallon size resealable plastic bag or equivalent container	~1,000 grams	Not Applicable	Not Applicable
Soil	Radiological (alpha spectroscopy)	HASL 300 A-01-R/ ST-RD-0210				
Soil	Radiological (gas flow proportional counting)	USEPA 905.0/ ST-RD-0403				

Notes:

[a] One container for all analyses. Separate containers not required.

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SAP Worksheet #20—Field Quality Control Sample Summary

Matrix	Analytical Group	Example No. of Sampling Locations[b]	No. of Field Duplicates	No. of MS/MSDs	No. of Field Blanks	No. of Equipment Blanks[a]	No. of PT Samples	Total No. of Samples to Lab
Soil	Radiological (gamma spectroscopy)	126	13	NA	1	7	NA	147
Soil	Radiological (alpha spectroscopy)	126	13	NA	1	7	NA	147
Soil	Radiological (gas flow proportional counting)	14	2	NA	1	7	NA	24

Notes:

[a] The number of field QC samples to be collected is dependent on the number of parent samples and the number of days of the sampling event.
- Field duplicates are collected at a frequency of 1 per 10 samples per matrix sent to the laboratory.
- Equipment Blank - For decontaminated equipment, one per type of sampling equipment, per site location; for disposable equipment, one per lot.
- Field Blank - One per source water per sampling event.

[b] The number of sample locations will be determined in the TSPs. An example is provided in this table for illustration purposes.

MS/MSD = matrix spike/matrix spike duplicate. Not applicable to radiological testing

PT = proficiency testing

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SAP Worksheet #21—Project Sampling SOP References

Radiological SOPs are specific to the activities being performed, the companies performing the work, and the radioactive material license used. These SOPs include radiological testing activities such as, radiation dose measurements, personnel monitoring, and radiological postings. Further, each company's SOPs may be different based on the requirements of their radioactive material license. Therefore, a comprehensive list and copies of radiological SOPs will be provided by CH2M, Cabrera, and Permafix as an attachment to the Radiological Work Plan. The following table includes a list of the available CH2M field SOPs that apply to the activities in this SAP. For clarity, a comprehensive list of applicable SOPs for each sampling location will be provided in TSPs as appropriate. Refer to **Worksheet #14** for project-specific procedural details.

Reference Number	Title	Date, Revision and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Yes/No)	Comments
NA	*Soil Sampling*	4/2015	CH2M	Hand Auger, Stainless Bowl, Spoon	No	
NA	*Logging of Soil Borings*	4/2015	CH2M	Radiation Detector	No	
NA	*Utility Locate*	4/2015	CH2M	N/A	No	
NA	*Decontamination of Personnel and Equipment*	6/2015	CH2M	Buckets	No	
NA	*Preparing Field Logbooks*	4/2015	CH2M	Log Book	No	
NA	*Chain-of-Custody*	4/2015	CH2M	chain-of-custody form	No	
NA	*Packaging and Shipping Procedures for Low-concentration Samples*	4/2015	CH2M	N/A	No	

Notes:
Field SOPs are presented in **Attachment 4**.

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SAP Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference	Comments
Ludlum Model 3 or 12 Meter with 44-9 detector (or equivalent); Ludlum Model 19 (or equivalent); Ludlum 2350-1 with 44-10 detector (or equivalent); Ludlum 2360 with 43-68 detector (or equivalent); Ludlum 2360 with 43-89 detector (or equivalent); Eberline Model RO-20 (or equivalent); GR 135 Exploranium (or equivalent); Ludlum Model 177 with HP- 210 detector (or equivalent)	1. Calibrate at lab featuring Nation Institute of Standards and Technology traceable standards 2. Operational checks and verifications	Annually Daily (prior to field use)	1. Pass/fail 2. +/- 20% of baseline response criteria	1. If recalibration fails, then instrument combination is retained/exchanged by instrument vendor. 2. If checks and verifications fail, then instrument combination tagged out of service/returned to instrument vendor for repair/exchange. Subsequently, data collected with instrument since previous QC check will be reviewed.	Field Team Leader or designee	Manufacturer's instruction manual	If equipment is deemed inoperable or is malfunctioning, it will be removed from use and replaced.
	Maintenance	Daily cleaning during field use; proper storage during inactive periods	Parameter readings as determined during calibration check	Follow procedure as outlined in the manufacturer's instruction manual or contact vendor technical support	Field Team Leader or designee	Manufacturer's instruction manual	If equipment is deemed inoperable or is malfunctioning, it will be removed from use and replaced.

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SAP Worksheet #23—Analytical SOP References

Lab SOP Number[a]	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
GL-RAD-A-013	The Determination of Gamma Isotopes, Revision 26, February 2017	Definitive	Soil - Radiological (gamma spec)	Gamma Spectrometer	GEL Laboratories, LLC	N
GL-RAD-A-011	The Isotopic Determination of Americium, Curium, Plutonium, and Uranium, Revision 26, October 2015	Definitive	Soil - Radiological (alpha spec)	Alpha Spectrometer	GEL Laboratories, LLC	N
GL-RAD-A-004	The Determination of Strontium 89/90 in Water, Soil, Milk, Filters, Vegetation and Tissues, Revision 18, February 2017	Definitive	Soil - Radiological (GFPC)	Gas Flow Proportional Counter	GEL Laboratories, LLC	N
GL-RAD-I-010	Procedure for Counting Room Instrumentation Maintenance, Revision 20, July 2014	NA	Soil -Radiological	NA	GEL Laboratories, LLC	N
GL-RAD-I-001	Gamma Spectroscopy System Operation, Revision 21, February 2017	NA	Soil –Radiological (gamma spec)	Gamma Spectrometer	GEL Laboratories, LLC	N
GL-RAD-I-009	Standard Operating Procedure for Alpha Spectroscopy System, Revision 15, May 2015	NA	Soil –Radiological (alpha spec)	Alpha Spectrometer	GEL Laboratories, LLC	N
GL-RAD-I-012	Managing Statistical Data in the Radiochemistry Laboratory, Revision 26, April 2016	NA	Soil -Radiological	NA	GEL Laboratories, LLC	N
GL-RAD-I-016	Multi-Detector Counter Operating Instructions, GL-RAD-I-016, Revision 10, April 2015	NA	Soil -Radiological	NA	GEL Laboratories, LLC	N

Notes:

[a] Laboratory SOPs are provided in Attachment 5

GFPC = gas flow proportional counting

spec = spectroscopy

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SAP Worksheet #24—Analytical Instrument Calibration

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Gamma Spectrometer	Initial Calibration (ICAL) (Energy, efficiency and FWHM peak resolution)	Prior to initial use, following repair or loss of control and upon incorporation of new or changed instrument settings.	The energy difference should be within 0.05% for all calibration points or within 0.2 keV. Peak energy difference is within 0.1 keV of reference energy for all points. Peak Full Width at Half Maximum (FWHM) < 3 keV at 1332 keV. The efficiency difference should be within 8% of the true value for each point unless T.C.C calibration is performed.	Correct problem, then repeat ICAL.	Analyst / Supervisor	ST-RD-0102
	Initial Calibration Verification (ICV)	After ICAL for energy/efficiency and prior to analysis of samples.	Observed peaks of second source standard fall within ± 10% of initial calibration value relative to the true value.	Verify second source standard and repeat ICV to check for errors. If that fails, identify and correct problem and repeat ICV or ICAL and ICV as appropriate.		
	Continuing Calibration Verification (CCV) Daily Check	Daily or prior to use. When working with long count times or batch sequences that run more than a day, CCV is performed at the beginning and end of each analytical batch as long as if not longer than a week.	Energy: ±0.5 keV at 60 keV; ± .75 keV at 1332 keV FW HM: ±1.2x at 60 keV; ±1.8x at 662 keV; ±2.3x at 1332 keV Activity Difference: %difference between the source activity and the reported activity ±5%	Correct problem, rerun CCV. If CCV rerun fails, repeat ICAL. Reanalyze all samples since the last successful calibration verification.		
	Background Subtraction Count Measurement (BSC) (Long count for subtracting background from blanks or test sources)	Immediately after ICAL and then performed on at least a monthly basis.	Background count rate of the entire spectrum with ±3σ of the average.	Recount and check control chart for trends. Determine cause, correct problem, re-establish BSC. If background activity has changed, re-establish BSC and reanalyze or qualify all impacted samples since last acceptable BSC.		
	Instrument Contamination Check (ICC) (Short count for controlling gross contamination)	Daily or when working with long count times before and after each analytical batch. Check after counting high activity samples.	No extraneous peaks identified (i.e., no new peaks in the short background spectrum compared to previous spectra); Background count rate of the entire spectrum with ±3σ of the average.	Recount the background. If still out of control, locate and correct problem; reanalyze or qualify all impacted samples since last acceptable ICC. If background activity has changed, re-establish BSC and reanalyze samples.	Analyst / Supervisor	ST-RD-0102
Alpha Spectrometer	Initial Calibration (ICAL) (Energy, efficiency and FWHM peak resolution)	Prior to initial use, following repair or loss of control and upon incorporation of new or changed instrument settings.	3 isotopes within energy range of 3-6 MeV Energy vs. channel slope equation <15 keV per channel. Full Width –Half Maximum (FWHM) ≤100 keV for each peak used for calibration. Final peak energy within 20 keV of reference energy Minimum of 3,000 net counts in each peak.	Correct problem, then repeat ICAL.	Analyst / Supervisor	ST-RD-0210
	Initial Calibration Verification (ICV)	After initial calibration.	FWHM ≤100 keV Each peak within ±20 keV ofcorresponding calibration peaks in initial energy calibration. Minimum 2000 net counts. Efficiency within 95% - 105% of initial calibration value.	Repeat ICV to check for error. If that fails, identify and correct problem and repeat ICV or ICAL and ICV, as appropriate.	Analyst / Supervisor	ST-RD-0210
	Continuing Calibration Verification (CCV) (Pulser check)	Pulser verification daily, prior to analysis of samples.	Gross counts within 5% of the average (20-point minimum). FWHM within 10-20 keV. Energy within ± 40 keV of the average (20-point minimum).	Recount and check control chart for trends. Determine cause, correct problem, and repeat CCV and all associated samples since last successful CCV.		
	Continuing Calibration Verification (CCV) (Check source)	Monthly source check verification prior to analysis of samples.	FWHM ≤100 keV Each peak within ±30 keV ofcorresponding calibration peaks in initial energy calibration. Minimum 2000 net counts. Efficiency within 95% - 105% of initial calibration value.	Recount and check control chart for trends. Determine cause, correct problem, and repeat CCV and all associated samples since last successful CCV.		

SAP Worksheet #24—Analytical Instrument Calibration (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Alpha Spectrometer	Background Subtraction Count (BSC) Measurement	Prior to initial use or after initial calibration and monthly.	Use a statistical test to determine a change in the background count rate value.	Check control chart for trends and recount. Determine cause, correct problem, re-establish BSC. If background activity has changed, re-establish BSC and reanalyze all impacted samples since last acceptable BSC.		
	Instrument Contamination Check (ICC)	Performed weekly, at minimum, and after counting high activity samples.	Blank ≤3 for blank subtracted (net) activity in all ROIs.	Check control chart for trends and recount. Determine cause and correct problem. If background activity has changed, re-establish BSC and reanalyze all infected samples.	Analyst / Supervisor	ST-RD-0210
Gas Flow Proportional Counter	Initial Calibration - Voltage Plateau (ICALV) (separate plateaus determined for alpha and beta activity)	Prior to initial use and after loss of control.	Slope of the plateau less than 5% over a range of 100V.	Correct problem, then repeat ICALV.	Analyst / Supervisor	ST-RD-0403
	Initial Calibration - Efficiency (ICALE)	Prior to initial use, after loss of control, and upon incorporation of new or changed instrument settings.	Verify manufacturer's specifications for detector efficiency for both alpha and beta counting modes using electroplated sources.	Correct problem, then repeat ICALE.		
	Initial Calibration – Cross-talk Factors (ICALCT)	Prior to initial use, after loss of control, and upon incorporation of new or changed instrument settings.	Verify manufacturer's specifications for cross-talk in alpha and beta channels.	Correct problem, then repeat ICALCT.	Analyst / Supervisor	ST-RD-0403
	Initial Calibration – Self-Absorption Curve (ICALSA)	Prior to initial use, after loss of control, and upon incorporation of new or changed instrument settings.	For each radionuclide of interest (or isotope with similar energy profile), establish mathematical function (curve) of detector efficiency vs. source mass loading. Best fit of data with coefficient of determination (r^2) ≥ 0.9.	Correct problem, then repeat ICALSA.		
	Efficiency Calibration Verification (IECV)	After ICALE for alpha and beta and prior to analysis of samples.	Individual points within ±30% of true value, average of points within ±10% of initial calibration value.	Correct problem and verify second source standard. Rerun IECV. If that fails, correct problem and repeat ICALE.		
	Continuing Calibration Verification (CCV)	After a counting gas change and daily for short test-source counting intervals.	Within tolerance or control chart limits ± 3% or 3σ of the mean.	Correct problem, rerun calibration verification. If that fails, then repeat ICALE. Reanalyze all samples since the last successful calibration verification.		

Notes:
The specifications in this table meet the requirements of DoD QSM v.5.0.

SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Gamma spectrometer	Liquid Nitrogen fill	Physical check	Physical check	Weekly	Acceptable background	• Recalibrate • Instrument maintenance • Consult with Technical Director	Analyst/Supervisor	GL-RAD-I-010
Alpha spectrometer	1. Vacuum Pump Oil replacement 2. Filter cleaning on the air intake of the instrument cabinet	1, 2. Physical check	1, 2. Physical check	1. Semi-annually 2. Quaterly	1, 2. Acceptable background and calibration efficiencies	• Recalibrate • Instrument maintenance • Consult with Technical Director	Analyst/Supervisor	GL-RAD-I-010
Gas Flow Proportional Counter	Sample Shelf Cleaning	Physical check	Physical check	Weekly	None applicable	None applicable	Analyst/Supervisor	GL-RAD-I-010

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Field Team/CH2M
Sample Packaging (Personnel/Organization): Field Team Leader/CH2M
Coordination of Shipment (Personnel/Organization): Field Team Leader/CH2M
Type of Shipment/Carrier: Overnight Carrier/ FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Receipt Staff/GEL Laboratories, LLC, LLC
Sample Custody and Storage (Personnel/Organization): Sample Receipt Staff/GEL Laboratories, LLC, LLC
Sample Preparation (Personnel/Organization): Various chemists and technicians /GEL Laboratories, LLC, LLC
Sample Determinative Analysis (Personnel/Organization): Various chemists and technicians/ GEL Laboratories, LLC, LLC
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 60 days from receipt
SAMPLE DISPOSAL
Personnel/Organization: Sample Disposal Staff/GEL Laboratories, LLC, LLC
Number of Days from Analysis: Any remaining sample volume will be returned under CoC for archiving to: CB&I Attn: Randall Kilpack/CB&I 200 Fischer Ave. Former Hunters Point Naval Shipyard San Francisco, CA 94124

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SAP Worksheet #27—Sample Custody Requirements

Soil Sample Identification Procedures

Each sample will be given a unique ID number that is carried through the entire process from sample collection to data reporting (see **Worksheet #18**). Samples will be assigned an alpha-numeric identifier that will be tied to the sampling location and sampling depth through a separate logbook that will be maintained in the field by the field sampling personnel. The field sampling personnel's logbook will be kept in addition to the chain-of-custody.

Sequential IDs may be pre-populated on the chain-of-custody and on waterproof sample labels, as described in **Worksheet #14**.

Field Sample Custody Procedures

Field sample custody procedures include sample collection, packaging, shipment, and delivery to the laboratory. Custody of field samples will be maintained and custody transfer will be documented from the time of sample collection through receipt of samples at the analytical laboratory using chain-of-custody and custody seal procedures. These requirements will be fulfilled by the CH2M Sample Management Coordinator. Each sample will be considered to be in the sampler's custody if the following occurs:

- The sample is in the person's physical possession.
- The sample is in view of the person after that person has taken possession.
- The sample is secured so that no one can tamper with the sample.
- The sample is secured in an area that is restricted to authorized personnel.

Field samples will be handled and prepared in the field for submittal to the analytical laboratory for analysis. Field personnel will use the following procedures when packing and transporting samples to the laboratory:

- Check samples for proper labeling and sample information.
- Waterproof metal or equivalent strength plastic coolers will be used for samples.
- Coolers will be lined with double garbage bags.
- Samples will be placed in resealable bags and placed inside of the garbage-bag-lined cooler.
- Samples that have similar holding times or special handling requirements will be packaged in the same cooler under the same chain-of-custody record.
- Samples will be checked for proper labeling and sample information.
- Paperwork (i.e., associated chain-of-custody records) will be placed in a double resealable plastic bag and taped to the inside lid of the cooler.
- The cooler will be taped and secured using signed custody seals.
- Signed custody seals will be placed on the front or both sides of the cooler before the custody of the cooler is relinquished to the overnight carrier or courier.

Chain-of-custody Procedures

The chain-of-custody record (an example is provided in **Attachment 5**) will document the transfer of sample custody from the time of sample collection to laboratory receipt and will accompany the samples from the field to the analytical laboratory. Samples will be shipped directly from the field to each analytical laboratory.

SAP Worksheet #27—Sample Custody Requirements (continued)

When custody of the samples is relinquished from one party to another, the individuals involved will sign, date, and record the time of transfer on the chain-of-custody record. The chain-of-custody records may consist of an original top copy and two carbonless copies, or the records may be in a pre-populated electronic format. When using the carbonless chain-of-custody format, the original and first copies will be transmitted to the primary analytical laboratory with the samples. The second copy will be retained in project files for the Field Team Leader, Project Chemist, and Database Manager. Upon transfer of the samples to the primary analytical laboratory, field personnel will sign and date the chain-of-custody forms. Field personnel will make a copy of the signed form and scan a copy of each chain-of-custody record to be saved electronically in the project files.

The chain-of-custody record will be completed by each field sampling team using waterproof ink. Corrections will be made with a single line-out, the error will be initialed and dated, and then the correct information will be entered. Empty fields on the chain-of-custody record will be crossed out with a single line or "Z'd" out, with the date and signature entered by the field sampling team. If samples are to be delivered to the laboratory by an overnight carrier, the airbill number will be recorded, and the chain-of-custody records will be placed in a waterproof plastic bag and taped to the inside lid of the sample cooler prior to sealing with appropriate secure tape and custody seals. These requirements will be fulfilled by the CH2M field sampling personnel.

Custody seals

Custody seals will be placed on the outside of each sample cooler so that the seals must be broken to open. After field samples are placed into coolers, two or more custody seals will be placed on the outside of the cooler prior to shipment or transport. Each custody seal will be initialed and dated by the field sampling team, affixed to the cooler, and taped over using clear strapping tape.

Laboratory Sample Custody Procedures

Laboratory sample custody procedures include the receipt of samples, archiving, and disposal. Custody of samples will be maintained and custody transfer will be documented from the time of sample receipt through sample disposal by the analytical laboratory consistent with the analytical laboratory's SOPs.

The analytical laboratories will have established custody procedures, which include the following:

- Designation of a sample custodian
- Completion by the custodian of the chain-of-custody record, any sample tags, and laboratory request sheets, including documentation of sample condition upon receipt
- Laboratory sample tracking and documentation procedures
- Secure sample storage with the appropriate environment (e.g., refrigerated, dry), consistent with analytical method requirements
- Proper data logging and documentation procedures, including custody of original laboratory records

Upon arrival of the samples at the analytical laboratory, a sample custodian will take custody of the samples, assess the integrity of sample containers, and verify that the information on the sample labels matches the information on the associated chain-of-custody record. The laboratory will restrict access to the storage areas to authorized laboratory personnel only, to prevent unauthorized contact with samples, extracts, or documentation. The sample custodian will maintain security of the samples in accordance with the analytical laboratory SOP.

Soil and field QC water samples will be retained for 60 days after final sample results are reported. Any remaining sample volume will be returned under chain-of-custody to HPNS for archiving.

SAP Worksheet #28a—Laboratory QC Samples Soil Gamma Spectroscopy

Matrix: Soil

Analytical Group: Radiological (gamma spec)

Analytical Method/SOP Reference: USEPA Method 901.1/GL-RAD-A-013

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per prep batch of 20 or fewer samples of similar matrix or one per day, whichever comes first	No analytes detected < RDL or less than 5% associated sample activity	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst/ Supervisor	Bias/Contamination	Same as Method/SOP QC Acceptance Limits
Laboratory Control Sample		Recovery Limits: Cs-137: 75-125% Co-60: 75-125% Am-241: 75-125%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples		Accuracy/Bias	
Laboratory Duplicate		RPD ≤25% and/or RER ≤1	Correct problem, then re-reanalyze all samples processed with the duplicate		Precision	

Notes:

DoD QSM v5.0 limits do not exist and the laboratory SOP limits will be used.

Cs = Cesium

LCS = laboratory control sample

MB = method blank

MDC = minimum detectable concentration

RER = relative error ratio

RPD = relative percent difference

Spec = spectroscopy

SAP Worksheet #28b—Laboratory QC Samples Soil Alpha Spectroscopy

Matrix: Soil

Analytical Group: Radiological (alpha spec)

Analytical Method/SOP Reference: USDOE Method HASL-300 A-01-R/ ST-RD-0210

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per prep batch of 20 or fewer samples of similar matrix or one per day, whichever comes first	No analytes detected > MDC	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst/ Supervisor	Bias/Contamination	Same as Method/SOP QC Acceptance Limits
Laboratory Control Sample		Recovery Limits: Pu-238: 80-127% Pu-239/240: 81–129% U-234: 84–120% U-238: 82-122% TH-232: 81 – 118%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples		Accuracy/ Bias	
Tracer	Per sample, blank, LCS, MS, MSD	Pu-242 tracer: 30–110% U-232 tracer: 30–110% Th-229 tracer: 30–110%	Truncate tracers above 100% recovery to eliminate low biased results. Reprepare and reanalyze sample if carrier is low (indicating high biased results) if there is activity in the sample above the reporting limit. No reanalysis if matrix interference is nonconformance during sample preparation		Accuracy/Bias	

Notes:
DoD QSM v5.0 limits do not exist and the laboratory SOP limits will be used.
LCS = laboratory control sample
MB = method blank
MDC = minimum detectable concentration
MS = matrix spike
MSD = matrix spike duplicate
Pu = Plutonium
Spec = spectroscopy

SAP Worksheet #28c—Laboratory QC Samples Soil Gas Flow Proportional Counting

Matrix: Soil

Analytical Group: Radiological (GFPC)

Analytical Method/SOP Reference: USEPA Method 905.0/ ST-RD-0403

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per prep batch of 20 or fewer samples of similar matrix or one per day, whichever comes first	No analytes detected > MDC	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst/ Supervisor	Bias/Contamination	Same as Method/ SOP QC Acceptance Limits
Laboratory Control Sample		Recovery Limits: 75-125%	Identify problem; if not related to matrix interference, re-reanalyze LCS and all associated batch samples		Accuracy/Bias	
Laboratory Duplicate		RPD ≤25% and/or RER ≤1	Correct problem, then re-reanalyze all samples processed with the duplicate		Precision	
Carrier	Per sample, blank, LCS, MS, MSD	Strontium and Yttrium carriers: 40-110%	Truncate Carriers above 100% recovery to eliminate low biased results. Reprepare and reanalyze sample if carrier is low (indicating high biased results) if there is activity in the sample above the reporting limit. No reanalysis if matrix interference is nonconformance during sample preparation		Accuracy/Bias	

Notes:

DoD QSM v5.0 limits do not exist and the laboratory SOP limits will be used.

GFPC = gas flow proportional counting

LCS = laboratory control sample

MB = method blank

MDC = minimum detectable concentration

MS = matrix spike

MSD = matrix spike duplicate

RER = relative error ratio

RPD = relative percent difference

Spec = spectroscopy

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SAP Worksheet #29—Project Documents and Records

Document	Where Maintained[a]
APP and Work Plan with SAP	CH2M Project files and NAVFAC SW Administrative Record
Field notes/logbooks	CH2M project file
Chain-of-custody forms	CH2M project file and analytical laboratory
Laboratory raw data	Analytical laboratory, CH2M project file, NAVFAC SW Administrative Record
Field audits/reports	CH2M project file
Corrective Action Report	CH2M project file and analytical laboratory
Laboratory equipment maintenance logs	CH2M project file and analytical laboratory
Sample preparation	CH2M project file, analytical laboratory, and NAVFAC SW Administrative Record
Run logs	CH2M project file, analytical laboratory, and NAVFAC SW Administrative Record
Sample disposal	CH2M project file and analytical laboratory
CLP-equivalent (Stage 4) analytical laboratory reports, including raw data	CH2M project file and NAVFAC SW Administrative Record
Hard copy data validation reports	CH2M project file and NAVFAC SW Administrative Record

Notes:

[a] Files will be stored for a minimum of 7 years in accordance with the CLEAN 9000 contract requirement.

Documents submitted to the NAVFAC SW Administrative Record will be consistent with the NAVFAC SW EWI #6 (Navy, 2005).

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SAP Worksheet #30—Analytical Services

Matrix	Analytical Group	Sample Locations/ ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/Organization (name and address, contact person and telephone number)	Backup Laboratory/ Organization[a] (name and address, contact person and telephone number)
Soil	Radiological	See **Worksheet #18**	USEPA Method 901.1 USDOE Method HASL 300 A-01-R USEPA Method 905.0	28 calendar days for full deliverable	GEL Laboratories, LLC2040 Savage Road Charleston, SC 29407 (843) 556-8171 POC: Valerie Davis	TBD

Notes:

[a] A backup laboratory has not been identified. If circumstances render the subcontracted laboratory unable to perform the analytical services, another laboratory will be determined at that time.

Samples will be analyzed by laboratories that are accredited by the DoD ELAP (Attachment 6).

GEL Laboratories DoD ELAP Certification Number 2567.01 (A2LA), Valid to June 30, 2017; Status of laboratory certifications/accreditations will be verified prior to field work and before samples are delivered to the laboratory. Updates to laboratory accreditation to ensure the laboratory is qualified to perform the analysis will be made prior to sample testing.

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SAP Worksheet #31—Planned Project Assessments

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (title and organizational affiliation)	Person(s) Responsible for Responding to Assessment Findings (title and organizational affiliation)	Person(s) Responsible for Identifying and Implementing CA (title and organizational affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (title and organizational affiliation)
Operational Readiness Review (ORR)	Project startup	Internal	CH2M	Radiological Lead CH2M	PM CH2M	PM CH2M	Radiological Lead CH2M
Field Sampling Technical Systems Audit (TSA)	At least one field TSA at the start of field activities	Internal	CH2M	Program Chemist (designee) CH2M	Field Team Leader CH2M	Field Team Leader CH2M	Radiological Lead CH2M
Data Review TSA	During field sampling and analysis through validation	Internal	CH2M	PM, Program Chemist CH2M	Field Team Leader (CH2M), Project Chemist, and Analytical Laboratory Manager	Project Chemist, Program Chemist (CH2M), and Analytical Laboratory Manager	Program Chemist CH2M

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (name, title, organization)	Time Frame of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (name, title, organization)	Time Frame for Response
ORR	ORR Checklist	Kim Henderson PM CH2M	As soon as possible, within same day of finding	ORR Checklist with outstanding actions completed or addressed prior to project work.	Kim Henderson PM CH2M	1 business day
Field Sampling TSA	Audit form (See Attachment 7) showing results of field audit. If CAs are necessary and cannot be implemented during the audit, these deficiencies will be noted and their resolution will be documented in the CA Report.	TBD Field Team Leader CH2M	As soon as possible within same day of finding	Completed Audit Form indicating all corrective actions taken. Additional documentation will be attached as necessary. Audit form is issued by the STC.	TBD Field Team Leader CH2M	1 business day
		Kim Henderson PM CH2M	1 business day		Kim Henderson PM CH2M	1 business day
		Anita Dodson Program Chemist CH2M	1 business day		Anita Dodson Program Chemist CH2M	3 business days
		Danielle Janda/ George (Patrick) Brooks LRPM/BLTL Navy	1 business day if CA involving > 1 day delay is necessary		Danielle Janda/ George (Patrick) Brooks LRPM/BLTL Navy	Included with summary report
Data Review TSA	Memo or written audit report	Anita Dodson Program Chemist CH2M	1 business day	Letter or e-mail	Anita Dodson Program Chemist CH2M	3 business days

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SAP Worksheet #33—QA Management Reports

Type of Report	Frequency (daily, weekly, monthly, quarterly, annually)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Data Quality Assessment (DQA) • Provides an overview of sampling, decontamination, and data storage procedures • Identifies QC samples and summarizes associated analytical results • Summarizes the findings of the analytical data validation process • Provides an evaluation of data quality in accordance with the data quality indicators as defined in the SAP	Once	Approximately 60 days after field investigation is complete	Program Chemist, CH2M STC, CH2M Project Chemist, CH2M	Navy LRPM/BLTL
Laboratory System Audit Reports	During DoD ELAP assessment or renewal of DoD ELAP certification	To be determined by DoD ELAP if offsite lab audit/ recertification is required	DoD ELAP Laboratory Evaluator	DoD ELAP POC (DoD ELAP) Laboratory Quality Assurance Managers
Field Sampling TSA Report	Once	Approximately 30 days after completion of audit	STC, CH2M	PM, CH2M and Navy LRPM/BLTL
Final Investigation Report	Once	60 days after field investigation	PM, CH2M	Persons listed on **Worksheet #3**

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SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process

Data Review Input	Description	Responsible for Verification or Validationa	Step I/ IIa/IIba	Internal/Externalb
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	Field Team Leader/CH2M	Step I	Internal
Chains of Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody will be initialed by the reviewer, a copy of the chains-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains-of-custody will also be reviewed for adherence to the SAP by the project chemist.	Field Team Leader/CH2M Project Chemist/CH2M	Step I	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the project chemist in the form of laboratory logins.	Project Chemist/CH2M	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the project chemist. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	Project Chemist/CH2M	Step I	External
Electronic Data Deliverables	Electronic Data Deliverables (EDDs) will be compared against hardcopy laboratory results (10% check).	Project Chemist/CH2M	Step I	External
Case Narrative	Case narratives will be reviewed by the data validator during the data validation process. This is verification that they were generated and applicable to the data packages.	Data Validator/CH2M	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Respective Laboratory Quality Assurance Officer	Step I	Internal
Laboratory Data	The data will be verified for completeness by the project chemist. In order to ensure completeness, EDDs will be compared to the SAP. This is a verification that all samples were included in the laboratory data and that correct analyte lists were reported.	Project Chemist/CH2M	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If corrective actions are required, a copy of the documented corrective action taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and corrective action forms will be reviewed internally to ensure that all appropriate corrective actions have been taken and that corrective action reports are attached. If corrective actions have not been taken, the site manager will be notified to ensure action is taken.	PM/CH2M Project Chemist/CH2M	Step I	Internal
Corrective Action Reports	Corrective action reports will be reviewed by the project chemist or PM and placed into the project file for archival at project closeout.	PM/CH2M Project Chemist/CH2M	Step I	External
Laboratory Methods	During the pre-validation check, ensure that the laboratory analyzed samples using the correct methods specified in the UFP-SAP. If methods other than those specified in the SAP were used, the reason will be determined and documented.	Project Chemist/CH2M	Step IIa	External
Target Compound List and Target Analyte List	During the pre-validation check, ensure that the laboratory reported all analytes from each analysis group as per Worksheets 15. If the target compound list is not correct, then it must be corrected prior to sending the data for validation. Once the checks are complete, the project manager is notified via email.	Project Chemist/CH2M	Step IIa	External
Reporting Limits	Ensure the laboratory met the project-designated quantitation limits as per Worksheet #15. If quantitation limits were not met, the reason will be determined and documented.	Project Chemist/CH2M	Step IIb	External
Field SOPs	Ensure that all field SOPs were followed.	Field Team Leader/CH2M	Step I	Internal
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Respective Laboratory Quality Assurance Officer	Step I	Internal
Raw Data	20 percent review of raw data to confirm laboratory calculations. For a recalculated result, the data validator attempts to re-create the reported numerical value. The laboratory is asked for clarification if a discrepancy is identified which cannot reasonably be attributed to rounding. In general, this is outside 5% difference.	Data Validator / TBD	Step IIa	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	Field Team Leader / CH2M	Step IIb	Internal

SAP Worksheet #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process (continued)

Data Review Input	Description	Responsible for Verification or Validation[a]	Step I/ IIa/IIb[a]	Internal/External[b]
Documentation of Method QC Results	Establish that all required QC samples were run and met limits.	Data Validator / TBD	Step IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run and met limits.	Project Chemist / CH2M	Step IIa	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP Certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	Project Chemist / CH2M	Step I	External
Analytical data for radiological parameters in all samples.	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. Data may be qualified if QA/QC exceedances have occurred. Guidance and qualifiers from " Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)" (USEPA; 2004), and "USEPA National Functional Guidelines for Inorganic Superfund Data Review (ISM02.2)" (USEPA, 2016b) may also be applicable.	Data Validator / TBD	Step IIa and IIb	External

Notes:

[a] Verification (Step I) is a completeness check that is performed before the data review process continues in order to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated is in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against measurement performance criteria in the SAP (both sampling and analytical). Should CH2M find discrepancies during the verification or validation procedures above, an email documenting the issue will be circulated to the internal project team, and a Corrections to File Memo will be prepared identifying the issues and the corrective action. This Memo will be sent to the laboratory, or applicable party, and maintained in the project file.

[b] Internal or external is in relation to the data generator.

SAP Worksheet #37—Usability Assessment

The usability assessment process will evaluate and document the usability of the data by considering the project DQIs or the precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) parameters, and whether the data will be suitable for the intended needs of the project. Every data type (for example, sampling, field screening data, and laboratory analytical data) will be relevant to the usability assessment. Data usability will include the entry of analytical data validation flags, applied by the third-party analytical data validation subcontractor, to the project data, as well as an overall assessment of the analytical data and field QC samples.

The assessment will consider each type of data, the relationship to the entire dataset, and the adequacy of the data to fulfill the project DQOs. The SDGs will be assessed for correctness, completeness and compliance to method- or project-specific QA/QC requirements, including the results of the independent analytical data validation process and contractual requirements. Analytical data validation will evaluate the data based on the PARCCS criteria defined in this SAP and other method-specific performance requirements. The overall assessment process will also evaluate data usability based on the intended use of the data.

The intent of the DQA process will be to establish the PARCCS levels and usability of the final results with respect to the project DQOs. Upon completion of analytical data validation, each data point will be assessed as non-qualified, qualified as estimated ("J" or "UJ" qualified), or qualified as rejected ("R" qualified) based upon the acceptance criteria, and analytical data validation flags will be added to the project data. These parameters will be based on the analytical data quality and will encompass the DQIs established in this SAP. Qualification will be given according to each sample's SDG and will be based on the SAP and applicable laboratory and data validation SOPs. Both analytical and contractual compliance and completeness levels will be assessed for each analytical parameter. Finally, the overall usefulness of the data will be established as related to the project DQOs.

Data Quality Indicators

Quantifiable criteria, known as measurement performance criteria, are presented in **Worksheet #12**. The PARCCS criteria will be the qualitative and quantitative indicators of data quality. The PARCCS criteria are defined and discussed as follows.

Precision

Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision will be measured by using laboratory duplicates and field duplicate samples. It will be expressed in terms of the RPD as follows:

$$RPD = \frac{|C_1 - C_2|}{(C_1 + C_2)/2} \times 100$$

where:

- RPD = relative percent difference
- C_1 = concentration of sample or MS
- C_2 = concentration of duplicate or MSD

SAP Worksheet #37—Usability Assessment (continued)

For the evaluation of precision between the native sample and its associated field duplicate, the sample results must be greater than 5 times the MDC in order for the RPD criteria (See **Worksheet #12**) to apply. When either the sample or field duplicate results are less than 5 times the MDC, then the RER must be less than 1 using the following equation:

$$RER = \frac{|S - D|}{2\sigma s + 2\sigma d}$$

where:

- *RER* = relative error ratio
- *S* = concentration of sample
- *D* = concentration of duplicate
- σs = uncertainty of sample result
- σd = uncertainty of duplicate result

If either the RPD or RER fail the criteria, the native sample and field duplicate results will be qualified as estimated ("J" flag). Other site specific field duplicate and laboratory duplicate results will be evaluated for trends and if the exceedance is due to the sample matrix or field sample collection, as well as if resampling is warranted. This evaluation and any impact related to constituents of concern/constituents of potential concern will provided in the data quality assessment.

Accuracy

Accuracy is the degree of agreement of an observed measurement (or an average of the same measurement type) with an accepted reference or true value. Accuracy of analytical determinations will be measured using laboratory QC analyses such as LCSs and surrogate spikes. Accuracy will be measured by evaluating the actual result against the known concentration added to a spiked sample and will be expressed as %R as shown below:

$$\%R = \frac{S - U}{C_{sa}} \times 100$$

where:

%R = Percent Recovery

- *S* = Measured concentration of spiked aliquot
- *U* = Measured concentration of unspiked aliquot
- C_{sa} = Concentration of spike added

Representativeness

Representativeness is the reliability with which a measurement or measurement system reflects the true conditions under investigation. Representativeness is influenced by the number and location of the sampling points, sampling timing and frequency of monitoring efforts, and the field and laboratory procedures. The representativeness of data will be maintained by the use of established field and laboratory procedures and their consistent application.

Comparability

Comparability expresses the confidence with which one dataset can be compared to another based on using USEPA-defined procedures, where available. If USEPA procedures are not available, the procedures have been defined or referenced in this SAP.

SAP Worksheet #37—Usability Assessment (continued)

The comparability of data will be established through well documented methods and procedures, standard reference materials, QC samples, performance-evaluation study results, and by reporting each data type in consistent units.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions. Analytical data validation and DQA will determine which data will be valid and which data will be rejected. Percent completeness will be defined as follows:

$$Percent\ Completeness = \frac{V}{T} \times 100$$

where:

- V = Number of valid (not rejected) measurements over a given time
- T = Total number of planned measurements

The completeness goal for this project will be 90 percent for valid, usable data. If the completeness goal of the project is not achieved, a discussion on the limitations on the use of the project data will be included in the Usability Assessment section of the final SAP.

Sensitivity

Sensitivity is the measure of a concentration at which an analytical method can positively identify and report analytical results. The sensitivity of an analytical method will be indicated by the project-required reporting limits, as compared to the PSLs.

Detection and Quantitation Limits

The MDC is an estimate of the smallest true activity (or activity concentration) of an analyte in a sample that ensures a 95 percent probability of detection, give a detection criterion that ensures on a 5 percent probability of detection in an analyte-free sample. The MDCs are contractually specified minimum detection limits for specific analytical methods and sample matrices.

For this project, concentrations below the MDC will be reported as “U” to the MDC.

Describe the evaluative procedures used to assess overall measurement error associated with the project:

The usability assessment process will consist of reviewing the analytical data validation reports for usable analytical data (i.e., no validation qualifications or estimated “J”/“UJ” qualifications) and rejected (“R” qualified) analytical data, as well as evaluating the field and analytical data for discrepancies or deviations. This assessment will evaluate the impact of the discrepancies or deviations on the usability of the data and assesses whether the necessary information has been provided for use in the decision-making process. The assessment will evaluate whether there were deviations in sampling activities (e.g., incorrect sample location, improper or malfunctioning sampling equipment, or incorrect analysis performed), chain-of-custody documentation, or holding times; compromised samples (i.e., damaged or lost samples) and the need to resample; or changes to SOPs or methods that could potentially affect data quality.

SAP Worksheet #37—Usability Assessment (continued)

An evaluation of QC sample results will be performed to assess whether unacceptable QC results (e.g., blank contamination) affect data usability.

Other parameters to be evaluated during the usability assessment may include, but will not be limited to, the following:

- Matrix effects—matrix conditions that might have affected the performance of the extraction or analytical method
- Site conditions—unusual weather conditions or site conditions that might have affected the sampling plan
- Identifying critical and noncritical samples or target analytes
- Background or historical data
- Data restrictions—data that do not meet the project DQOs or were "R" qualified might be restricted, but usable, as qualitative values for limited decision-making purposes

The data will be evaluated for overall PARCCS criteria for each matrix, analytical group, and concentration level, and data use limitations will be discussed in the DQA report for data that do not meet the project DQOs or DQIs.

Identify the personnel responsible for performing the usability assessment:

Project Chemist, CH2M, Mark Cichy

Data Validation Subcontractor, TBD

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented, so that they identify trends, relationships (correlations), and anomalies:

Usability assessment results will be reported in the Confirmation Survey Report.

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Figures

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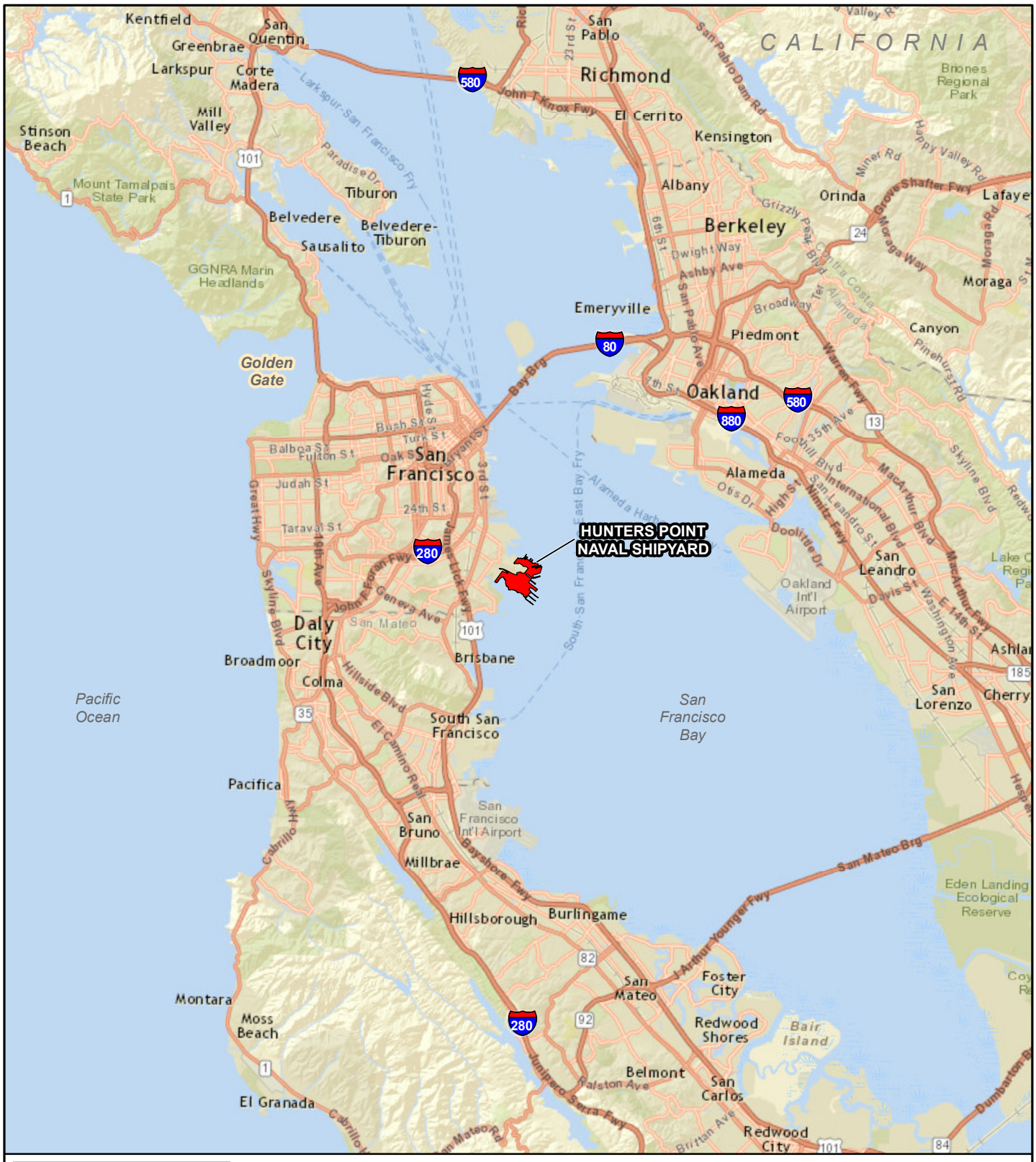


LEGEND

Installation Boundary

IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
World Street Map

Figure 10-1
Installation Location
Uniform Federal Policy for Sampling and Analysis Plan
Hunters Point Naval Shipyard, San Francisco, California

N

0 2 4

1 inch = 4 miles

LEGEND

PARCEL NAME

- A-1
- A-2
- B-1
- B-2
- C
- D-1
- D-2
- E
- E-2
- F (Pier)
- F (Water)
- G
- IR Sites 07/18
- UC-1
- UC-2
- UC-3

NOTE:
IR = Installation Restoration

IMAGERY SOURCE:
ESRI ArcGIS Online Web Service,
NAIP, 06/08/2014

Figure 10-2
Site Layout
Uniform Federal Policy for Sampling and Analysis Plan
Hunters Point Naval Shipyard, San Francisco, California

0 500 1,000
Feet
1 inch = 1,000 feet
N

R:\ENBG\00_Proj\NNavy\CLEAN\SOUTHWEST\HUNTERS_POINT_NS\MapFiles\FZ_012\UFP\SAP\012_0146.mxd 2/3/2017 lm046933CH2M

Attachment 1
Project Scoping Meeting Minutes

MEETING SUMMARY

Hunters Point Naval Shipyard Scoping Meeting San Francisco, California

ATTENDEES:	Derek Robinson, Navy Pat Brooks, Navy Bill Franklin, Navy Danielle Janda, Navy Lily Lee, EPA RPM David Yogi, EPA Jackie Lane, EPA Tamsen Drew, OCII (Office of Community Investment and Infrastructure) Amy Brownell, SFDPH Scott Hay, Cabrera Services Janet Naito, DTSC Nina Bacey, DTSC Sheetal Singh, CDPH	Jeff Wong, CDPH Tina Low, Water Board Kellie Koenig, CH2M Robert Kirkbright, CH2M Adam Engel, CH2M *On Phone:* Matt Slack, RASO Zach Edward, RASO LCDR Soric, RASO Dr. Steve Doremus, RASO Jana Dawson, Tech Law Mark Luckhardt, Five Point Lindsay Land, EPA Carla Brazen
DATE:	December 13, 2016	
PROJECT:	Navy CLEAN 9000, CTO-FZ12	

Objectives

The objectives of the meeting were to introduce team members, discuss radiological data evaluation and community outreach activities, and gain feedback, input, and buy-in from stakeholders.

Introduction

A presentation and schedule were provided to all invitees prior to the meeting.

Derek Robinson from the BRAC PMO kicked off the meeting by thanking everyone for attending, and stated how important this project is for the Navy, BRAC, the City of San Francisco, Regulatory Agencies, and developers. He stated the urgency of this effort and the requirement to get it done right the first time. Lily Lee mentioned the EPA will be sending a letter outlining recommended actions. Derek also said that this venue is a good place for everyone to meet face to face. Pat Brooks and CH2M will be presenting the strategy and scope of the planned efforts which hopefully can draw to a close any unanswered questions

Introductions were made.

The Tiger Team points of contact were identified:

NAVY - Pat Brooks, Derek Robinson, Danielle Janda, Zachary Edwards, and Matthew Slack

DTSC - Janet Niato and Nina Bacey

EPA - John Chestnut and Lily Lee

CDPH - Sheetal Singh and Jeff Wong

Water Board – Tina Low

City of San Francisco - Tamsen Drew (OCII) and Amy Brownell (SFDPH)

Bob Kirkbright began the presentation with a brief discussion of the team CH2M has assembled, pointing out the challenge in finding experts for the team that have not been involved with Tetra Tech or its affiliates and subcontractors to avoid any possible perception of a conflict of interest. The assembled team consists of a consortium of experienced experts from CH2M and other recognized radiological companies to provide an independent third party analysis of the data. He mentioned CH2M has been in contact with Dr. Covello to consult on the outreach messaging efforts; Dr. Covello indicated he would be available after the New Year.

Pat Brooks explained this project is BRAC's number one priority, and they will be putting all their efforts toward facilitating its completion.

Scott Hay presented what has been accomplished so far, and explained the technical approach to the project.

Pat Brooks reiterated the challenges of balancing the aggressive schedule with the thorough analysis this project demands. He indicated a substantial amount of rework has taken place, including past efforts by RASO and Tetra Tech, using approaches that identified anomalous data. It was mentioned there were additional accusations after those efforts were completed. The CH2M team will perform an independent analysis that will include reviewing those efforts as well as performing additional analysis of the data.

Technical Approach

Scott Hay presented the phased approach and accomplishments to date.

Questions were raised about the database regarding how it was going to be examined. Scott Hay and Pat Brooks explained the first steps are to determine the completeness of the data set. Sample IDs can be used to break out survey units, and arrange them by parcel to form data subsets.

A discussion was had about why 2006 was determined as the starting point. The EPA expressed concerns that Tetra Tech was working at Hunters Point in the 1990s and their Health Physicists have identified anomalies in some of the pre 2006 data that they reviewed. Pat Brooks explained that 2006 was used as the cutoff because that was when the TCRA to remove sewer lines began, and everything before that was characterization and preliminary surveys, not used to determine final status. It was decided that any data that was used for decision making needs to be reviewed, and Derek Robinson and Pat Brooks agreed to look into the data that was used to determine work was complete. EPA, DTSC, and the project team agreed if the pre 2006 data was superseded by other work done after 2006, it does not need to be analyzed.

A discussion was held regarding scope. It was explained that during the initial phase, only soil data will be reviewed. In later phases of the project, buildings scans and gamma statics will be evaluated as well. Items such as lab EDDs and field notebooks will be requested as needed as potential issues are identified.

Lily Lee expressed they have been getting a lot of questions on parcels that have already been transferred. Scott Hay explained that we are including all locations where Tetra Tech has worked, and analyzing all of their data. Further concerns were expressed regarding the data that does not show any obvious anomalies. It is her opinion that since Tetra Tech has disclosed that data has been falsified, we cannot say that the data is reliable even though the statistical tests do not turn up any results. Scott Hay and Bob Kirkbright explained that our statistical tests will identify anomalies in the data, including running tests designed to identify instances where data may have been falsified. It was agreed that areas of highest potential risk should be the priority.

Sheetal Singh asked questions about what types of tests were going to be run, and how it is known whether they are effective. Scott Hay explained we will be using a test on the data sets where problems have already been identified, as well as the data set in its entirety. If these tests are able to identify the known problem areas, it will provide confidence in the analysis. Scott Hay went on to describe the statistical test and how the analysis was going to be approached in more detail, and explained that phase two will determine the amount and locations of confirmation sampling.

EPA raised questions of the amount of confirmation sampling, and what approach will be taken if data testing methods do not recommend sampling in places where allegations have pointed to. Scott Hay explained that confirmation sampling will be done to address specific issues, including allegations from former workers, if that is deemed appropriate. It was discussed that allegations of misconduct do not necessarily mean that there is a health risk. Danielle Janda stated that the Navy was fully committed to doing a resampling effort, with the extent to be determined. Scott stated the North Pier will probably be used as a test run analysis.

Pat Brooks mentioned this initial effort will examine static gamma readings, building scans, and soil data; only the soil data will be included in the initial analysis with the target completion in January 2017. Laboratory electronic data and gamma walk-over data has been requested from TetraTech. During the discussion it was noted that split sample results are not in NIRIS, so those would have to be obtained separately from the agency that conducted the analysis.

Community Outreach

Kellie Koenig provided a handout of the proposed format for the Draft Radiological Community Engagement Communications Plan, and presented the Community Involvement objectives, approach, tasks, and schedule. The following was discussed:

The group recommended adding the Water Board and Non-Regulatory City departments to the list of stakeholders. Key stakeholders will be included from all available lists including the 2014 CIP.

Tamsen Drew stated that the City recommends four languages, and with the known local population recommended public documents be provided in English, Spanish, written Chinese, Samoan, and Tagalog.

The communication efforts will include preparation of and frequently updating a FAQ sheet with answers generated through the Tiger Team.

EPA and City of San Francisco representatives expressed the community is very interested in being informed and involved throughout the duration of the project. The topic of fact sheets and the subjects of each one were discussed. It was suggested that a third fact sheet be added between sheet one and two in order to inform public about initial findings and explaining how the Navy is going to proceed. David Yogi of EPA expressed importance of keeping the community involved throughout the process, not just telling them what we did after it was complete.

Derek Robinson expressed his desire to present at the Mayor's Hunters Point Shipyard Citizen's Advisory Committee (CAC). Tamsen Drew stated that the CAC would be interested.

Additional Public Outreach discussion yielded the ideas that will be discussed further:

- Be proactive, not reactive.
- Get the community involved early in the process and bring them along the process to build trust.
- The possibility of EPA getting a third party technical advisor to help communicate technical aspect to the public. Agency grant availability information should be communicated to CBOs.
- Multiple feedback mechanisms for public communication are beneficial.

- Respond as quickly as possible to community concerns and give consistent responses; essential to building trust.
- Create a list of FAQs to facilitate fast and consistent responses to community questions.
- Go to reporters directly to get them involved, so they do not misinterpret what is going on. The Navy has specific reporters they have worked with in the past.
- Local "door to door" outreach has been successful in the past. Coordination with local churches and community groups has also been successful. A community liaison may help facilitate.
- Choose venues that facilitate the open exchange of information.
- Present Navy, EPA, State, City as a unit.
- Look into attending preexisting meetings
- Public stakeholders prefer information via Email.
- The District Supervisor expressed an interest to be involved.
- The community outreach team resolved to have a call twice per month for two months.

Tamsen Drew raised concern about CH2M's past involvement at Hunters Point, and how the community may react to having a company with past history at the site doing the third party evaluation. Bob Kirkbright explained the differences in CH2M's history and what occurred with Tetra Tech. It is recognized that a cohesive message is necessary to explain how the situations were vastly different, including the response by the companies; the CH2M team performing this review will include recognized senior experts from at least three other independent companies; and this effort will receive continuous independent scrutiny by the Federal, State, and Tiger Team members.

David Yogi of the EPA suggested that there are groups that will never change their distrust level and efforts are better spent on stakeholders who want to hear the facts and learn about current activities. He also brought up having a Technical Advisor, separate from CH2M and the Navy. Recommendations included Saul Bloom, and Kai Vetter. Pat Brooks commented that the Navy is working to involve a National Laboratory (such as Argonne National Laboratory), but it has not been contracted due to the time it takes to get them on board.

Bill Franklin discussed 3 key points:

- Need to identify the best forums and look for reasons to say "Yes" to outreach opportunities and venues to exchange information.
- Tiger Team to share public inquiries and answers to ROIs with the group to ensure a consistent message.
- Tiger Team participation in outreach and outreach planning meetings so that stakeholder interaction is productive and respectful.

Action Items

Determine if pre 2006 data was used for decision making – Pat Brooks

Provide library of compiled questions and answers on community outreach to share with team – Lily Lee

Plan twice a month Community outreach team check in meeting – Derek Robinson

Email copy of Draft Radiological Community Engagement Plan Communications Plan to RASO – Kellie Koenig

Attachment 2
Example Test Pit Log

PROJECT NUMBER	TEST PIT NUMBER SHEET __ OF ___

TEST PIT LOG

PROJECT : LOCATION : LOGGER :

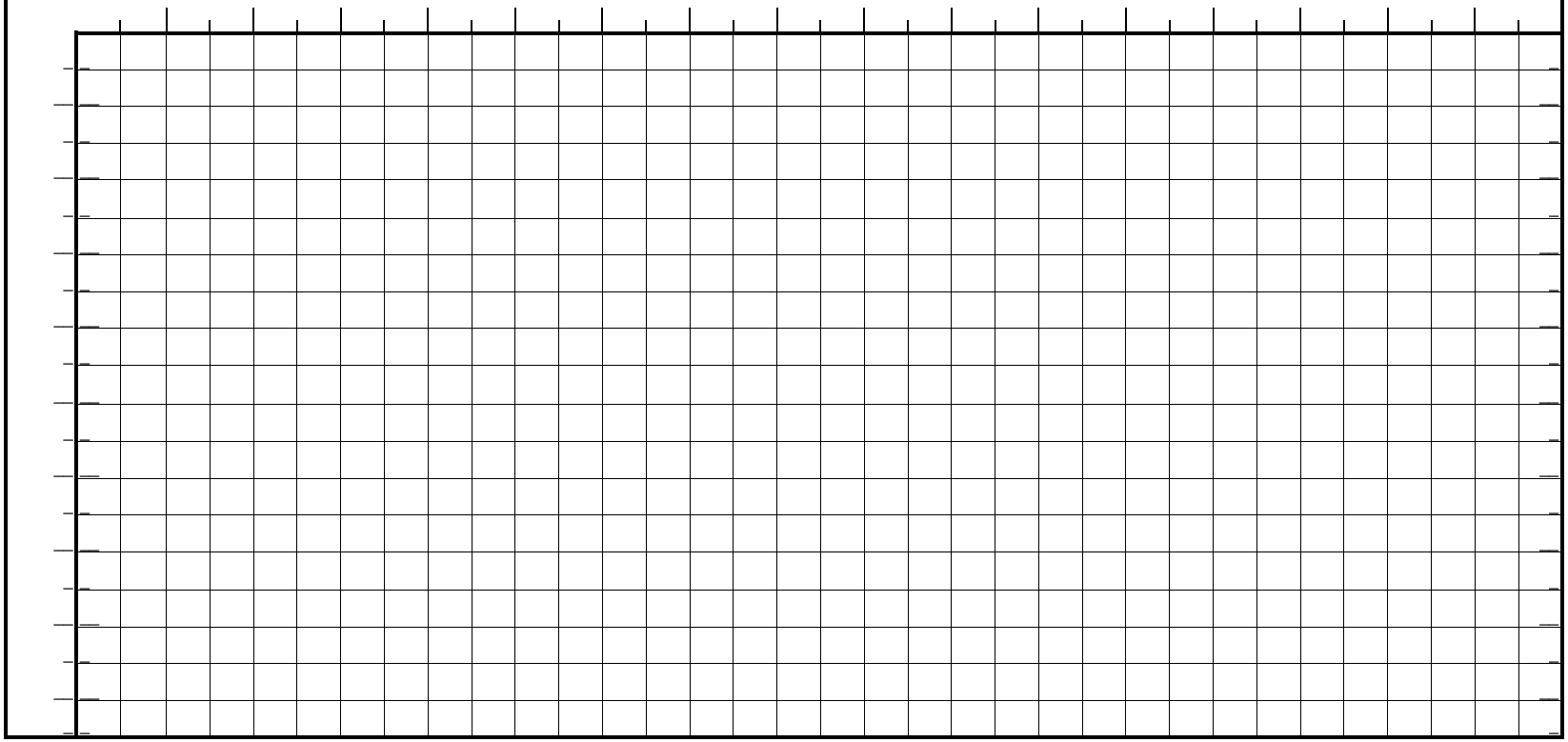
ELEVATION : CONTRACTOR :

EXCAVATION EQUIPMENT USED : DATE EXCAVATED:

WATER LEVEL : APPROX. DIMENS: Length: Width: Max. Depth:

DESCRIPTION	COMMENTS
SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	DIFFULCULTY IN EXCAVATION, RUNNING GRAVEL, CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, GRADATIONAL CONTACTS, TESTS, INSTRUMENTS, WATER SEEPAGE

TEST PIT DIMENSIONS (FT)



Attachment 3
Example Soil Boring Log

	PROJECT NUMBER	BORING NUMBER
ch2m.		

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

ATD WATER LEVEL : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS. PID Readings: Breathing Zone: Above Hole:

Attachment 4
Field SOPs

STANDARD OPERATING PROCEDURE

Soil Sampling

I. Purpose and Scope

The purpose of this SOP is to provide guidelines that must be followed on Navy CLEAN projects for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Stainless-steel, split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP *Decontamination of Drilling Rigs and Equipment*. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel or dedicated wooden tongue depressor is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP *Shallow Soil Sampling.*

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight ("hammer") dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 *Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

ASTM D 1587 *Standard Practice for Thin-Walled Tube Sampling of Soils* (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

(Visual-Manual Procedure)
D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D 4220 Practices for Preserving and Transporting Soil Samples
D 4633 Test Method for Energy Measurement for Dynamic Penetrometers
D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D 6026 Practice for Using Significant Digits in Geotechnical Data
D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead*, *n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods*, *n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value*, *n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT)*, *n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil*, *n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly*, *n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer*, *n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system*, *n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide*, *n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns*, *n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods*, *n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

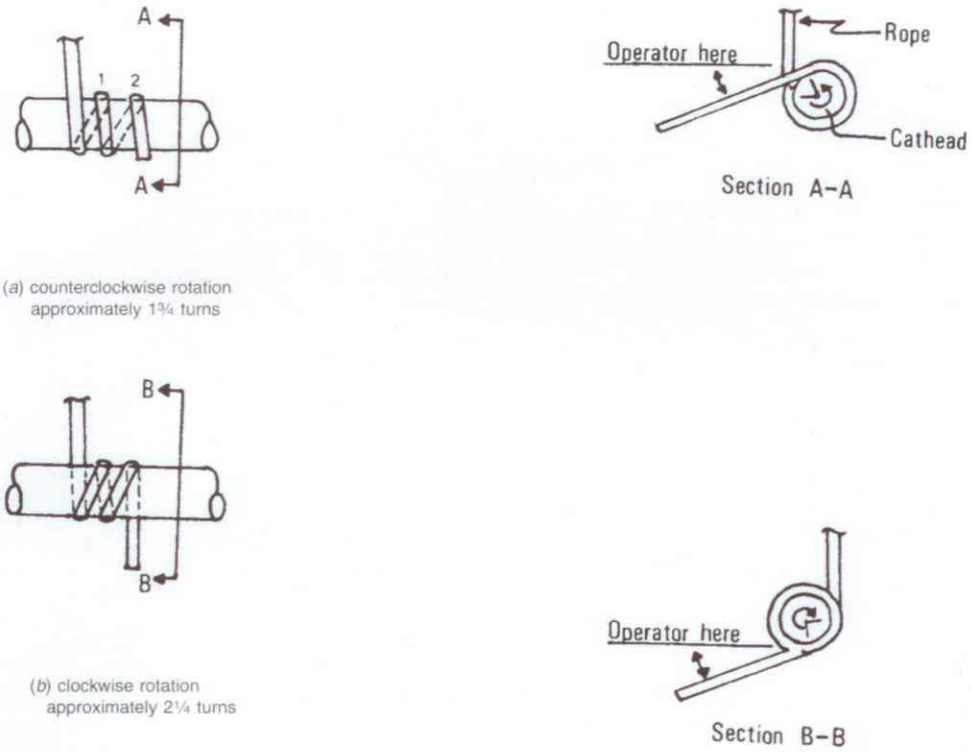


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

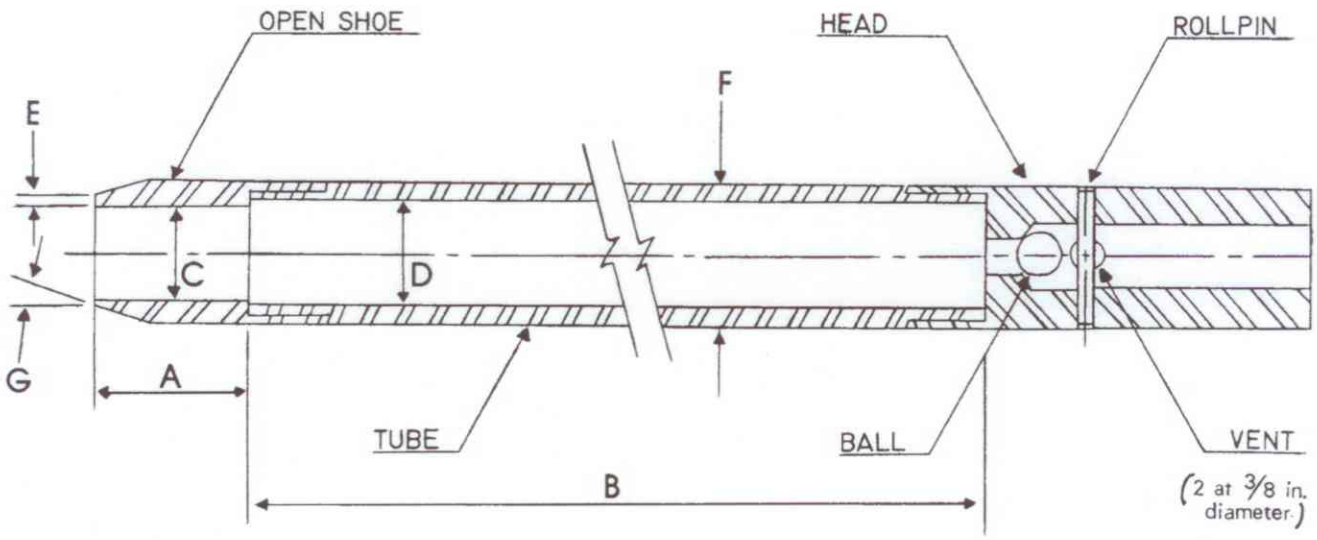
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

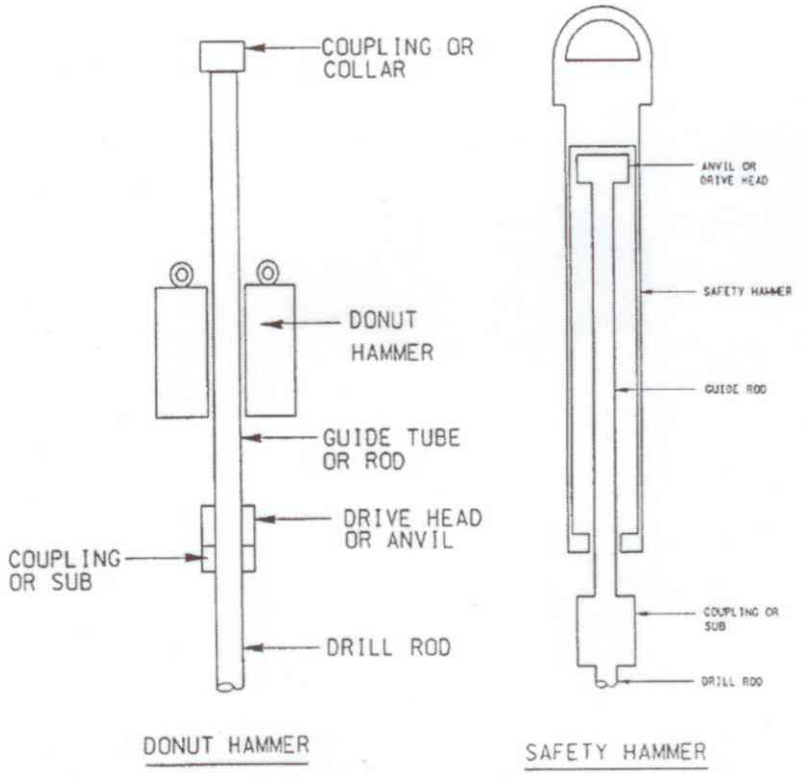


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

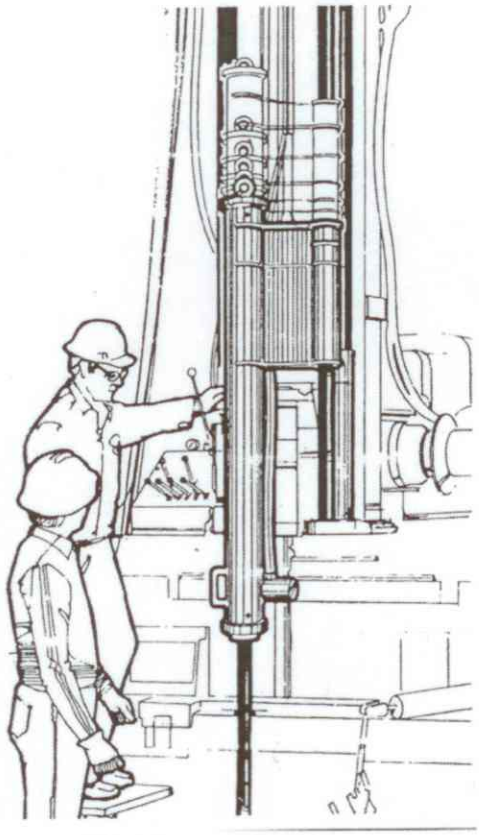


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

DRILLERS BORING LOG

Project: _____ Project No: _____ Boring No: _____

Location: _____ Sheet _____ of _____

Date Started: _____ Date Completed: _____

Drill Crew:

Boring Location
Station _____ Offset _____

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type _____

Method Of Drilling:

Auger _____ Size _____

Wash _____ Water _____ Mud _____

Hammer Type

Auto _____ Manual _____

Split-Spoon Type

Length _____ Liner Used _____

Boring Size _____ Bit Used _____

Casing Size _____ Length _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____ Time _____

@ _____ Date _____ Time _____

@ _____ Date _____ Time _____

Cave-in Depth

@ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
(2) Scope was completely revised.
(3) Referenced Documents updated to include new standards.
(4) Terminology: added section on Definitions.
(5) Significance and Use: clarified use of the SPT test.
(6) Apparatus: general editorial changes.
(7) Sampling and Testing Procedure: general editorial changes.
(8) Data Sheets/Forms: general editorial changes.
(9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

Designation: D 1587 – 00 (Reapproved 2007)$^{\epsilon 1}$

Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ϵ^1 NOTE—Editorial changes were made in June 2007.

1. Scope*

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452, D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 1 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved May 1, 2007. Published July 2007. Originally approved in 1958. Last previous edition approved in 2003 as D 1587 – 03.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

TABLE 1 Dimensional Tolerances for Thin-Walled Tubes

Nominal Tube Diameters from Table 2[A] Tolerances						
Size Outside Diameter	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inside clearance ratio, %, n*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality, n*—the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

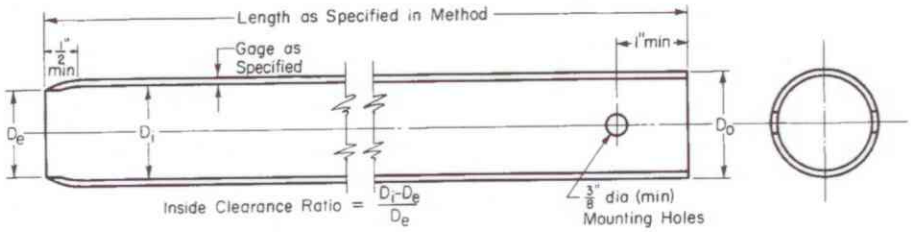
5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice. are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
⅜	9.53
½	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

TABLE 2 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %	<1	<1	<1

[A] The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 2 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 1.

6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample con occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 2.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil

sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled "top".

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 "Guide for Field Logging of Subsurface Explorations of Soil and Rock". This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured,

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 200, which may impact the use of this standard.

(1) Added parts of speech to terms.

(2) Corrected reference in Note 2 from D 5740 to D 3740.

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil density of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil

description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."

2. Group symbol, in parentheses, for example, "(SP)."

3. Color, using Munsell color designation

4. Moisture content

5. Relative density or consistency

6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).

- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

CH2M HILL Form D1586 and a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

CH2M HILL

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT _____ LOCATION _____

ELEVATION _____ DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

WATER LEVELS _____ START _____ FINISH _____ LOGGER _____

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG, FORM D1586

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
DEN 22371.G5	BL-3	1	3

SOIL BORING LOG

PROJECT Howard Ave Landslide LOCATION Howard & 24th Ave, Centennial, CO
ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado
DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig
WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5					
	4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
	5.0					
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H_2S odor, many fine roots up to about 1/4 inch	Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
	8.0					
	10.0	3-ST	1.3	——	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730
	15.0					Driller notes rough drilling action and chatter @ 13 ft
15	15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
	20.0					Driller notes smoother, firm drilling @ 19 ft
20	21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot. tip of 6-S, poss boulders or rock
	23.0					Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

(47) MAY 12, 2003 EXAMPLE

0715 ARRIVE ON SITE AT XYZ SITE.
CH2M HILL STAFF:
John Smith: FIELD TEAM LEADER
Bob Builder: SITE SAFETY COORD.
WEATHER: OVERCAST + COOL, 45°F
CHANCE OF LATE SHOWERS
SCOPE: • COLLECT GROUNDWATER SAMPLES FOR LTM WORK AT SITE 14
• SUPERVISE SURVEY CREW AT SITE 17
0725 BB ~~Cal~~ (JS) CALIBRATES PID: 101 ppm/100 ppm OK
PID MODEL #, SERIAL #
0730 BB CALIBRATES HORIBA METER MODEL #, SERIAL #
→ LIST CALIBRATION RESULTS
0738 SURVEY CREW ARRIVES ON SITE
→ LIST NAMES
0745 BB HOLDS H+S TALK ON SLIPS, TRIPS, FALLS, TICKS + AIR MONITORING
JS + SURVEY CREW ATTEND
NO H+S ISSUES IDENTIFIED AS CONCERNS. ALL WORK IS IN "LEVEL D."
0755 JS CONDUCTS SITE-WIDE AIR MONITORING
ALL READINGS = 0.0 ppm IN

JS 5-12-03

(48) MAY 12, 2003 EXAMPLE

SITE 14 LTM
BREATHING ZONE (BZ)
0805 MOBILIZE TO WELL MW-22 TO SAMPLE, SURVEYORS SETTING UP AT SITE 17
0815 PM (PAUL PAPER PUSHER) CALLS AND INFORMS JS TO COLLECT GW SAMPLE AT WELL MW-44 TODAY FOR 24 hour TAT ANALYSIS OF VOC'S
0820 PURGING MW-22
→ RECORD WATER QUALITY DATA

JS 5-12-03

0843 COLLECT SAMPLE AT MW-22 FOR TOTAL TAL METALS AND VOC'S. NO DISSOLVED METALS NEEDED PER PM.
0905 JS + BB MOBILIZE TO SITE 17 TO SHOW SURVEYORS WELLS TO SURVEY.
0942 MOBILIZE TO WELL MW-22 TO COLLECT SAMPLE
0950 CAN NOT ACCESS WELL MW-22 DUE TO BASE OPERATIONS; CONTACT PAUL PAPERPUSHER AND HE STATED HE WILL CHECK ON GAINING ACCESS WITH BASE CONTACT.
0955 MOBILIZE TO WELL MW-19

JS 5-12-03

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93ε1.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula.*

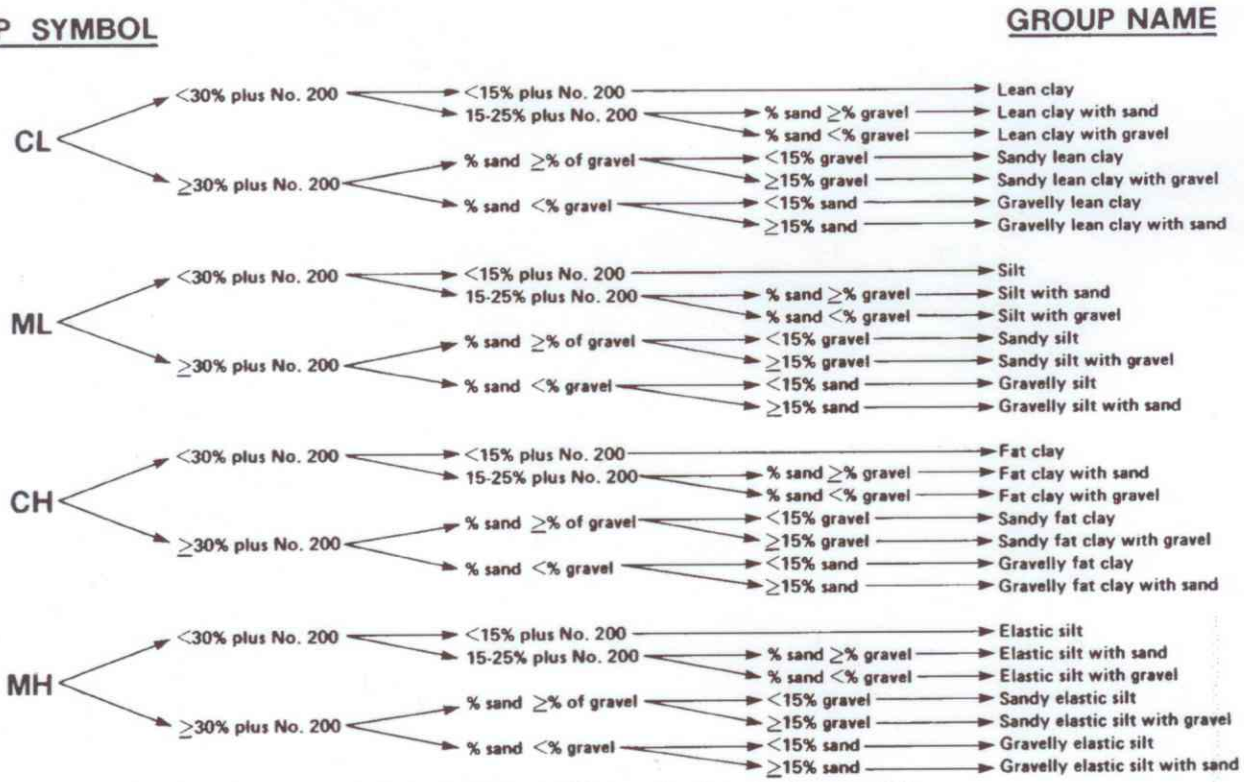
6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

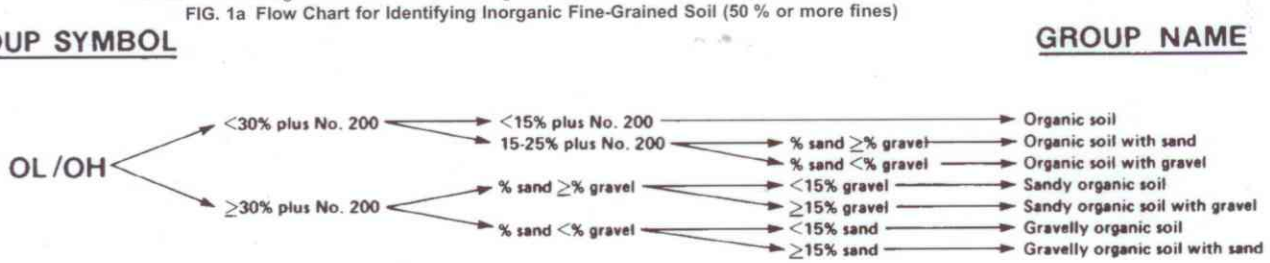
7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

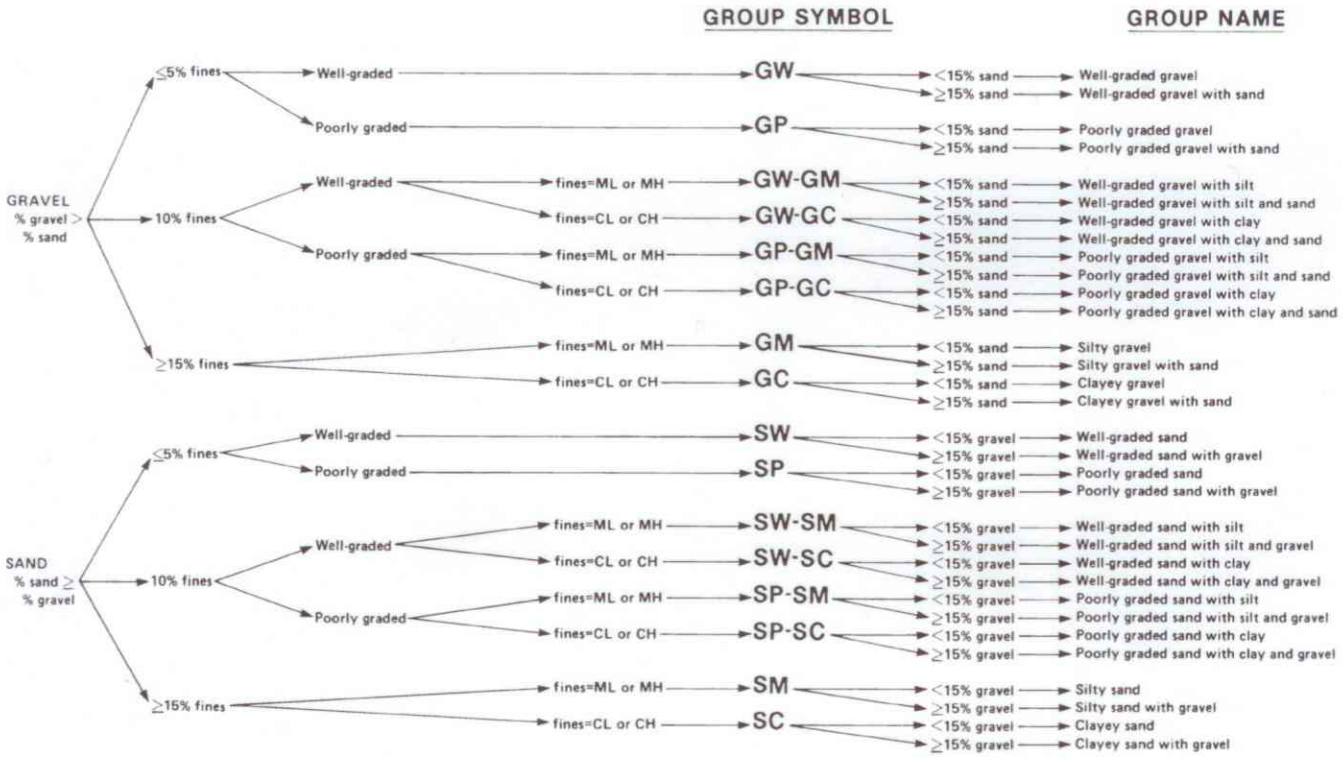
NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

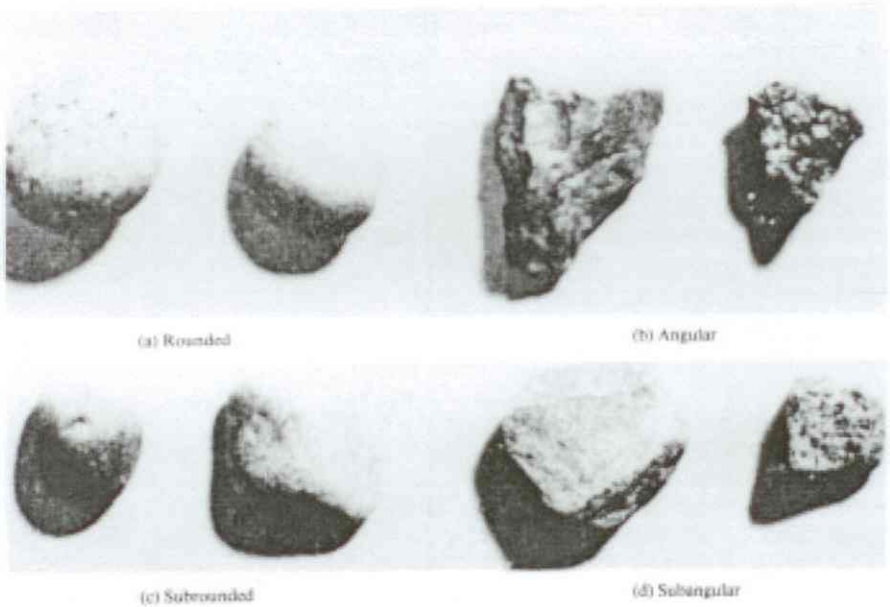


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

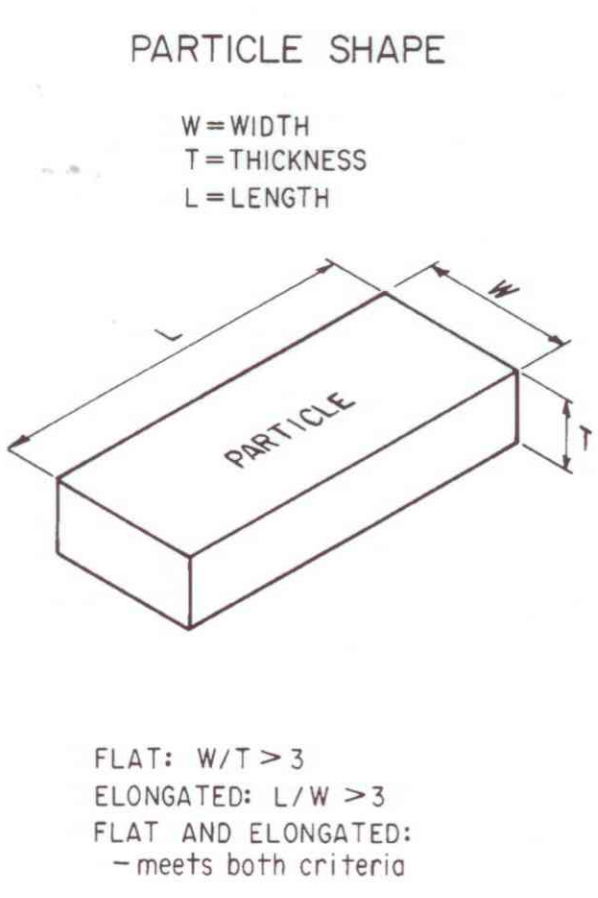


FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:

s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993$^{\varepsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

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[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

(Visual-Manual Procedure)
D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D 4220 Practices for Preserving and Transporting Soil Samples
D 4633 Test Method for Energy Measurement for Dynamic Penetrometers
D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D 6026 Practice for Using Significant Digits in Geotechnical Data
D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead*, *n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods*, *n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value*, *n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT)*, *n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil*, *n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly*, *n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer*, *n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system*, *n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide*, *n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns*, *n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods*, *n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

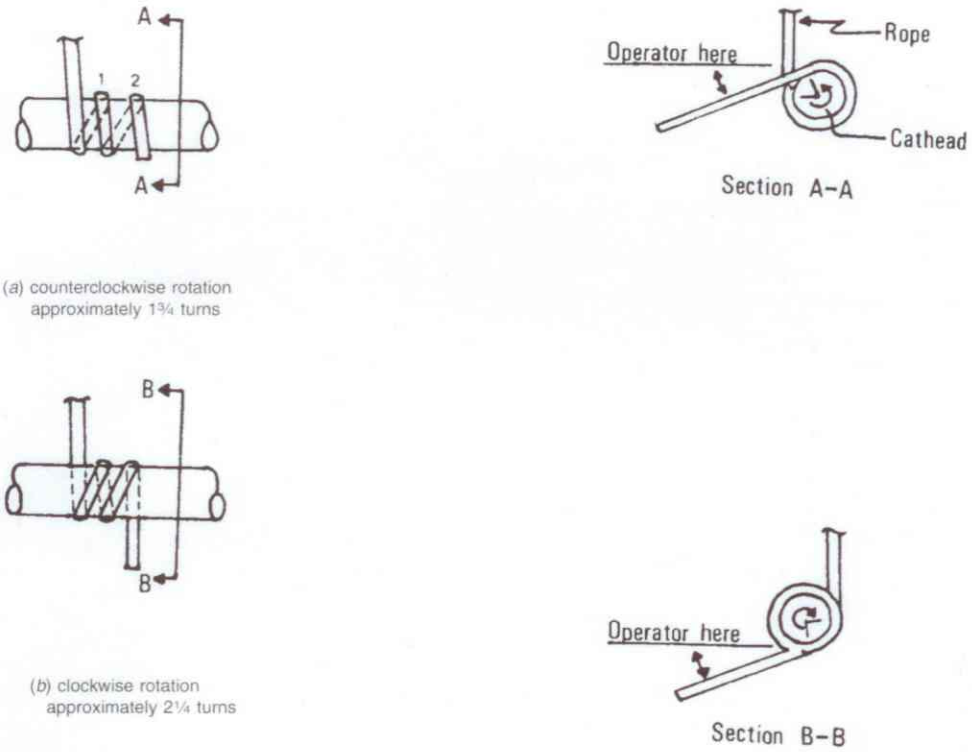


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

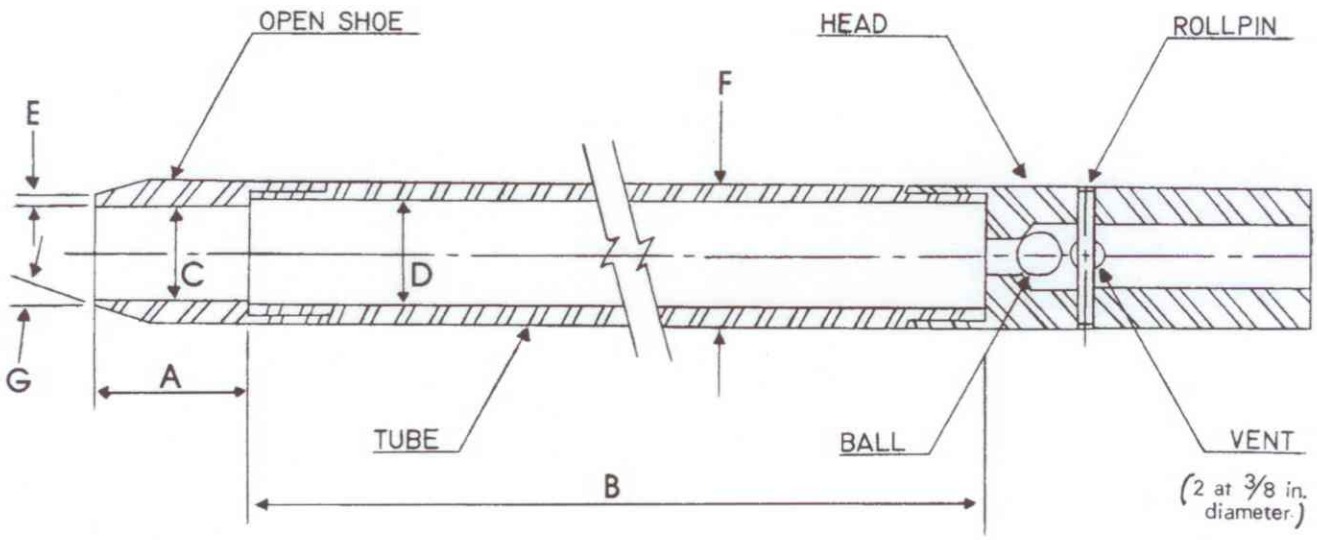
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

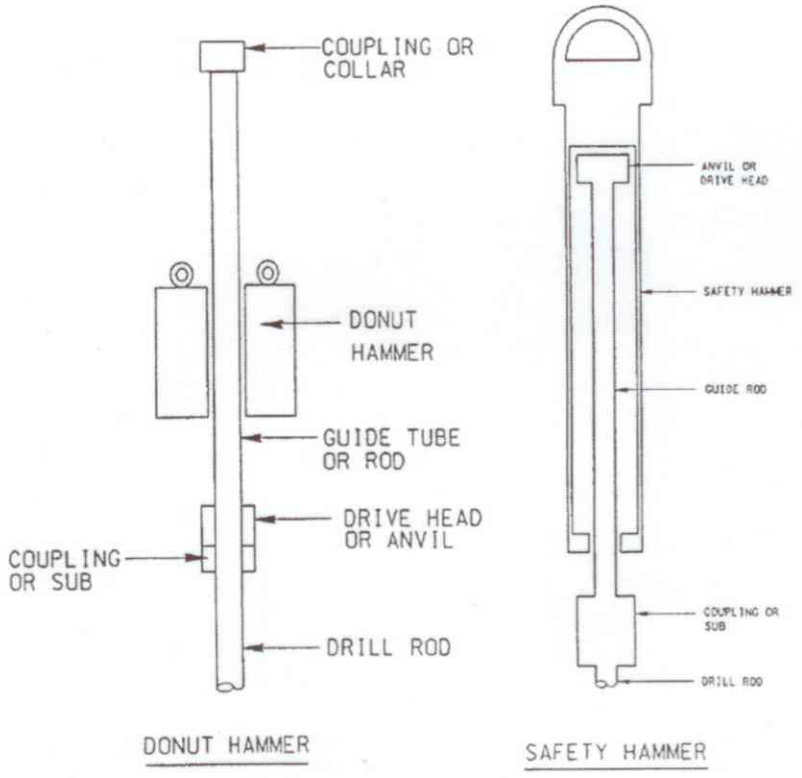


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

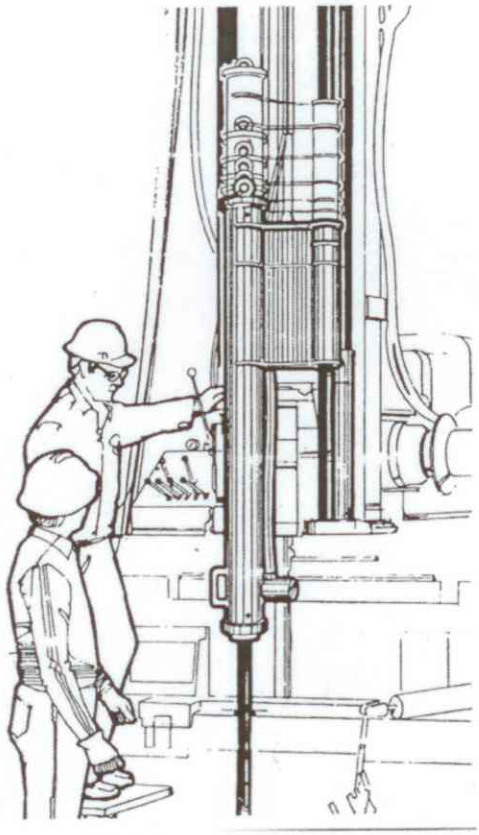


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

DRILLERS BORING LOG

Project: _____ Project No: _____ Boring No: _____

Location: _____ Sheet _____ of _____

Date Started: _____ Date Completed: _____

Drill Crew:

Boring Location
Station _____ Offset _____

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type _____

Method Of Drilling:

Auger _____ Size _____

Wash _____ Water _____ Mud _____

Hammer Type

Auto _____ Manual _____

Split-Spoon Type

Length _____ Liner Used _____

Boring Size _____ Bit Used _____

Casing Size _____ Length _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____ Time _____

@ _____ Date _____ Time _____

@ _____ Date _____ Time _____

Cave-in Depth

@ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(1) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
(2) Scope was completely revised.
(3) Referenced Documents updated to include new standards.
(4) Terminology: added section on Definitions.
(5) Significance and Use: clarified use of the SPT test.
(6) Apparatus: general editorial changes.
(7) Sampling and Testing Procedure: general editorial changes.
(8) Data Sheets/Forms: general editorial changes.
(9) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Standard Operating Procedure

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to CH2M HILL and its subcontractors and health and safety risks to our project staff.

This SOP shall be used by Activity Managers and Project Managers to, in-turn, develop Activity-specific and project-specific utility location procedures. The activity and project-specific procedures will become part of work plans and project instructions and will be used to prepare scopes of work (SOWs) for the procurement of utility location subcontractors to meet the needs of individual projects.

This SOP also identifies the types of utility locating services that are available from subcontractors and the various tools that are used to locate utilities, and discusses when each type of service and tool may or may not be applicable.

II. Scope

Depending on the Navy/Marine Activity we typically find ourselves in one of two scenarios:

Scenario 1

The Activity provides utility locating (or dig clearance) services through the public works department or similar organization, or has a contract with an outside utility clearance service. Some of these services are provided in the form of dig permits which are required before you can dig or drill. In other cases, no official permit is required and the process is somewhat vague.

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on CH2M HILL to clear the dig locations.

Table 1 provides an up to date summary of which scenarios apply to the various primary Activities served under the Navy CLEAN program.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations

using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So while the Navy's process may protect us from liability for property damage, it does not adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

Therefore, regardless of what services the Navy provides, in most cases we still need to supplement this effort with clearance services from our own third party utility location subcontractor following the procedures and guideline outlined in Section IV of this SOP. The cost implications of providing this service will range from $500 to several $1,000 depending on the size of the project.

The scope of services that we ask our subcontractors to provide can involve utility marking/mapping or the clearing of individual dig locations. In the former we ask our subs to mark all utilities within a "site" and often ask them to prepare a map based on their work. In the later, we ask them to clear (identify if there are any utilities within) a certain radius of a proposed dig/drill location.

The appropriate requested scope of services for a project will depend on the project. Clearing individual boreholes is often less expensive and allows the sub to concentrate their efforts on a limited area. However, if the scope of the investigation is fluid (all borehole locations are not predetermined) it may be best to mark and map an entire site or keep the subcontractor on call.

Clearance of individual dig locations should be done to a minimum 20-foot radius around the location.

An example SOW for a utility subcontractor procurement is provided in Attachment A.

III. Services and Equipment

This section provides a general description of the services available to help us locate subsurface utilities and describes the types of equipment that these services may (or may not) use to perform their work. It identifies the capabilities of each type of equipment to help the PM specify what they should require from our utility location subs.

Services

The services that are available to us for identifying and marking underground utilities are:

- The local public/private utility-run service
- Utility location subcontractors (hired by us)

Attachment B provides a detailed description of each type of organization. It also provides contact numbers and web sites for the various organizations in the areas where we do work for the Navy and contacts and services provided by several subcontractors that we have used or spoken to in the past.

Equipment

Attachment C provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the PM determine if the equipment being used by a subcontractor is adequate.

It is important to make the potential subcontractors aware of the possible types of utilities (and utility materials) that are at the site, and to have them explain in their bid what types of equipment they will use to locate utilities /clear dig locations, and what the limitations of these equipment are.

A list of in-house experts that can be used to help you evaluate bids or answer questions you may have is provided in **Appendix C.**

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by CH2M HILL and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These "dig permit" requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

Identify Activity-specific permit and/or procedural requirements for excavation and drilling activities. Contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Activity Specific: To be provided by Activity or Project Manager

CH2M HILL Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by CH2M HILL as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to CH2M HILL) to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include (these are further described in Attachment C):

- **Ground Penetrating Radar (GPR),** which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.
- **Radio Frequency (RF),** involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.

- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF
- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers,** are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. ***The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.***
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the CH2M HILL-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The CH2M HILL subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. ***This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.***
- Marking shall be done using the color coding presented in Attachment E. The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their

sidewalks and streets. ***Any particular marking requirements need to be provided in the subcontractor SOW.***

- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by CH2M HILL, when the dig location (e.g. mechanical drilling, excavating) is expected to be within 5 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

A- Example SOW for Utility Location Subcontractor Procurement
B - Services Available for Identifying and Marking Underground Utilities
C – Equipment Used for Identifying Underground Utilities
D – Utility Clearance Documentation Form
E – Utility Marking Color Codes

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-FZ12

Scope of Work

Subsurface Utility Locating

Site XX

Radiological Data Evaluation and Confirmation Survey, Former Hunter's Point Naval Shipyard

San Francisco, CA

A licensed and insured utility locator will be subcontracted to identify and mark out subsurface utilities for an environmental investigation/remediation project at Site XX of Hunter's Point Naval Shipyard, San Francisco, CA. The subcontractor will need to be available beginning at <<insert time>> on <<insert date>>. It is estimated that the work can be completed within XX days.

Proposed Scope of Work

The subcontractor will identify and mark all subsurface utilities (CHOOSE 1) that lie within a radius of 20 feet of each of XX sampling locations at Site XX shown on the attached Figure 1; (OR) that lie within the bounds of Site XX as delineated on the attached Figure 1. (If multiple sites are to be cleared, provide maps of each site with sample locations or clearance boundaries clearly delineated and a scale provided.)

Utilities will be identified using all reasonably available as-built drawings, electronic locating devices, and any other means necessary to maintain the safety of drilling and sampling personnel and the protection of the base infrastructure. The location of utilities identified from as-built drawings or other maps must be verified in the field prior to marking.

Base utility drawings for the Site(s) (CHOOSE 1) can be found at <<insert specific department and address or phone number on the base>> and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by CH2M HILL upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

Field verification will include detection using nonintrusive subsurface detection equipment (magnetometers, GPR, etc) as well as opening manhole covers to verify pipe directions. As part of the bid, the Subcontractor shall provide a list of the various subsurface investigation tools they propose to have available and use at the site and what the limitations are of each tool.

A CH2M HILL representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1)** ***a 20-ft radius of the XX proposed soil boring locations*** **(OR)** ***within the boundary of the site(s)*** as identified on the attached figure(s) will be marked using **paint** ***(some Bases such as the WNY may have restrictions on the use of permanent paint)*** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the ***Buried Utility Location Tracking Form*** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to CH2M HILL (field staff or project manager) within 24 hours of completing the utility locating activities.

(OPTIONAL) ***The subcontractor shall also provide a map (or hand sketch) of the identified utilities to the Engineer within XX days of field demobilization. The map shall include coordinates or ties from fixed surface features to each identified subsurface utility.***

Bid Sheet/Payment Units

The subcontractor will bid on a time and materials basis for time spent on site and researching utility maps. Mobilization (including daily travel to the site) should be bid as a lump sum, as well as the preparation of the AHA and any required mapping. The per diem line item should be used if the field crew will require overnight accommodations at the project site.

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of CH2M HILL.

The subcontractor shall also prepare and provide to the Engineer, at least 48 hours prior to mobilization, an acceptable Activity Hazard Analysis (AHA) using the attached AHA form or similar.

It is also required that all subcontractor personnel who will be on site attend the daily 15-minute health and safety tailgate meeting at the start of each day in the field.

Subcontractor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employers will be notified. Subcontractor personnel under the influence of prescription or over-the-counter medication that may impair their ability to operate equipment will not be permitted to do so. It is expected that the subcontractor will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

Security

The work will be performed on US Navy property. CH2M HILL will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to CH2M HILL, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

- Name
- Birth Place
- Birth Date
- Social Security Number
- Drivers License State and Number
- Citizenship

Please be advised that no weapons, alcohol, or drugs will be permitted on the Navy facility at any time. If any such items are found, they will be confiscated, and the Subcontractor will be dismissed.

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of California and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer's recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the CH2M HILL Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor's personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the CH2M HILL representative to resume operations. Subcontractor standby time also will include potential delays caused by the CH2M HILL representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the

Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

Cumulative Subcontractor standby will be accrued in increments no shorter than 15 minutes (i.e., an individual standby episode of less than 15 minutes is not chargeable).

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and CH2M HILL representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on CH2M HILL's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and CH2M Hill representative's daily logs. No payment will be made for down time.

Schedule

It is anticipated that the subsurface utility locating activities will occur on <<insert date>>. It is estimated that the above scope will be completed within XXX days.

Attachment B - Services Available for Identifying and Marking Underground Utilities

The services that are available to us for identifying and marking underground utilities are:

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility
- Utility location subcontractors (hired by CH2M HILL)

Each are discussed below.

Navy Public Works Department

A Public Works Department (PWD) is usually present at each Activity. The PWD is responsible for maintaining the public works at the base including management of utilities. In many cases, the PWD has a written permit process in place to identify and mark-out the locations of Navy-owned utilities [Note: The PWD is usually NOT responsible for the locations/mark-outs of non-Navy owned, public utilities (e.g., Washington Gas, Virginia Power, municipal water and sewer, etc.). Therefore, it is likely that we will have to contact other organizations besides the PWD in order to identify non-Navy owned, public utilities].

At some Activities, there may not be a PWD, the PWD may not have a written permit process in place, or the PWD may not take responsibility for utility locating and mark-outs. In these cases, the PWD should still be contacted since it is likely that they will have the best understanding of the utility locations at the Activity (i.e., engineering drawings, institutional knowledge, etc.). Subsequently, the PWD should be brought into a cooperative arrangement (if possible) with the other services employed in utility locating and mark-out in order to have the most comprehensive assessment performed.

At all Activities we should have a contact (name and phone number), and preferably an established relationship, with PWD, either directly or through the NAVFAC Atlantic, Midlant, or Washington NTR or Activity Environmental Office that we can work with and contact in the event of problems.

Miss Utility or "One Call" Services for Public Utility Mark-outs

Miss Utility or "One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Ms. Utilities and is part of the response process for Miss Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs

to be performed. The "One Call" services are free to the public. Note that the "One Call" centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the "One Call" center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility "One Call" center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

For the Mid-Atlantic region, the following "One Call" service centers are available.

Name	Phone	Website	Comments
Miss Utility of DELMARVA	800-257-7777	www.missutility.net	Public utility mark-outs in Delaware, Maryland, Washington, DC, and Northern Virginia
Miss Utility of Southern Virginia (One Call)	800-552-7001	not available	Public utility mark-outs in Southern Virginia
Miss Utility of Virginia	800-257-7777 800-552-7007	www.missutilityofvirginia.com	General information on public utility mark-outs in Virginia, with links to Miss Utility of DELMARVA and Miss Utility of Southern Virginia (One Call)
Miss Utility of West Virginia, Inc	800-245-4848	none	Call to determine what utilities they work with in West Virginia
North Carolina One Call Center	800-632-4949	www.ncocc.org/ncocc/default.htm	Public Utility Markouts in North Carolina

Private Subcontractors

1. Utility-locating support is required at some level for most all CH2M HILL field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort, including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

   The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and recent construction is limited, CH2M HILL may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult,

CH2M HILL will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately $200 per day for a simple EM effort (usually one crew member and one instrument) to approximately $1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

The following table provides a list of recommended geophysical surveying support subcontractors that can be used for utility-locating services:

Company Name and Address	Contact Name and Phone Number	Equipment[1]					Other Services[2]		
		1	2	3	4	5	A	B	C
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			4					
Utilities Search, Inc.*	Jim Davis 703-369-5758	4				4	4	4	4
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	4					4	4	4
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	4	4						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	4	4	4	4	4	4	4	4
Earth Resources Technology. Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	4	4	4	4	4	4	4	
Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	4	4	4	4	4	4	4	4

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that CH2M HILL requests for this type of work at many Navy sites.

[1]Equipment types are:

1. Simple electromagnetic instruments, usually hand-held
2. Other, more innovative, electromagnetic instruments, including larger instruments for more area coverage
3. Ground-penetrating radar systems of all kinds
4. Audio-frequency detectors of all kinds
5. Radio-frequency detectors of all kinds

[2]Other services include:

A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.

B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.

C. Concrete/asphalt coring and pavement/surface restoration.

Attachment C – Equipment Used for Identifying Underground Utilities

This attachment provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the AM and PM determine if the equipment being proposed by a subcontractor or Navy is adequate. A list of in-house experts that can be used to answer questions you may have is provided below.

CH2M HILL In-house Utility Location Experts

Tamir Klaff/WDC

Home Office Phone – 703-669-9611

Electromagnetic Induction (EMI) Methods

EMI instruments, in general, induce an electromagnetic field into the ground (the primary field) and then record the response (the secondary field), if any. Lateral changes in subsurface conductivity, such as caused by the presence of buried metal or by significant soil variations, cause changes in the secondary field recorded by the instrument and thus enable detection and mapping of the subsurface features. It should be noted that EMI only works for electrically conductive materials--plastic or PVC pipes are generally not detected with EMI. Water and gas lines are commonly plastic, although most new lines include a copper "locator" strip on the top of the PVC to allow for detection with EMI.

EMI technology encompasses a wide range of instruments, each with inherent strengths and weaknesses for particular applications. One major division of EMI is between "time-domain" and "frequency-domain" instruments that differ in the aspect of the secondary field they detect. Another difference in EMI instruments is the operating frequency they use to transmit the primary field. Audio- and radio-frequencies are often used for utility detection, although other frequencies are also used. Consideration of the type of utility expected, surface features that could interfere with detection, and the "congestion" of utilities in an area, should be made when choosing a particular EMI instrument for a particular site.

One common EMI tool used for utility location is a handheld unit that can be used to quickly scan an area for utilities and allows for marking locations in "real time". This method is most commonly used by "dig-safe" contractors marking out known utilities prior to excavation. It should be noted that this method works best when a signal (the primary field) can be placed directly onto the line (i.e., by clamping or otherwise connecting to the end of the line visible at the surface, or for larger utilities such as sewers, by running a transmitter through the utility). These types of tools also have a limited capability to scan an area for unknown utilities. Usually this requires having enough area to separate a hand held transmitter at least a hundred feet from the

receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

In addition to the handheld EMI units, larger, more powerful EMI tools are available that provide more comprehensive detection and mapping of subsurface features. Generally, data with these methods are collected on a regular grid in the investigation area, and are then analyzed to locate linear anomalies that can be interpreted as utilities. These methods will usually detect *all* subsurface metal (above a minimum size), including pieces of abandoned utilities. In addition, in some situations, backfill can be detected against native soils giving information on trenching and possible utility location. Drawbacks to these methods are that the secondary signals from utilities are often swamped (i.e., undetectable) close to buildings and other cultural features, and that the subsurface at heavily built-up sites may be too complicated to confidently interpret completely.

Hand-held metal detectors (treasure-finders) are usually based on EMI technology. They can be used to locate shallow buried metal associated with utilities (e.g., junctions, manholes, metallic locators). Advantages of these tools is the ease of use and real-time marking of anomalies. Drawbacks include limited depths of investigations and no data storage capacity.

Ground Penetrating Radar (GPR)

GPR systems transmit radio and microwave frequency (e.g., 80 megaHertz to 1,000 megaHertz) waves into the ground and then record reflections of those waves coming back to the surface. Reflections of the radar waves typically occur at lithologic changes, subsurface discontinuities, and subsurface structures. Plastic and PVC pipes can sometimes be detected in GPR data, especially if they are shallow, large, and full of a contrasting material such as air in a wet soil, or water in a dry soil. GPR data are usually collected in regular patterns over an area and then analyzed for linear anomalies that can be interpreted as utilities. GPR is usually very accurate in x-y location of utilities, and can be calibrated at a site to give very accurate depth information as well. A significant drawback to GPR is that depth of investigation is highly dependant on background soil conductivity, and it will not work on all sites. It is not uncommon to get only 1-2 feet of penetration with the signal in damp, clayey environments. Another drawback to GPR is that sites containing significant fill material (e.g., concrete rubble, scrap metal, garbage) will result in complicated anomalies that are difficult or impossible to interpret.

Magnetic Field Methods

Magnetic field methods rely on detecting changes to the earth's magnetic field caused by ferrous metal objects. This method is usually more sensitive to magnetic metal (i.e., deeper detection) than EMI methods. A drawback to this method is it is more susceptible to being swamped by surface features such as fences and cars. In addition, procedures must usually be implemented that account for natural variations in the earth's background field as it changes throughout the day. One common use of the method is to measure and analyze the gradient of the magnetic field, which eliminates most of the drawbacks to the method. It should be noted this method only detects

ferrous metal, primarily iron and steel for utility location applications. Some utility detector combines magnetic and EMI methods into a single hand-held unit.

Optical Methods

Down the hole cameras may be useful in visually reviewing a pipe for empty conduits and/or vaults.

Attachment D – Utility Clearance Documentation Form

Attachment E – Utility Marking Color Codes

The following is the standard color code used by industry to mark various types of utilities and other features at a construction site.

White – Proposed excavations and borings

Pink – Temporary survey markings

Red – Electrical power lines, cables, conduits and lighting cables

Yellow – Gas, oil, steam, petroleum or gaseous materials

Orange – Communication, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

Buried Utility Location Tracking Form

(Submit to CH2M HILL PM within 24 hrs of location activities)

Project Location:
CH2M HILL Project No.:
CH2M HILL Project Manager: Name/Phone:
Fax:
Email:
CH2M HILL Field Team Leader: Name/Phone:

CH2M HILL Purchase Order:

Utility Location Subcontractor:
Subcontractor POC:

Dates of location activities:

Check each box using an "X" if a buried utility is present within 5 feet of a marked Station ID. If color of the flag or paint differs from listed color, note change in color on the form.

Station ID	Gas (Yellow)	Electric (Red)	Fiber optic (Orange)	Cable (Orange)	Water (Blue)	San. Sewer (Green)	Storm Sewer (Green)	Steam (Yellow)	Petroleum (Yellow)	Compressed air (Yellow)	Other ____	Other ____	Other ____	Other ____	Date completed	Technician initials	Notes (methods/tools used

The findings of the buried utility location activities summarized herein were conducted in strict accordance with the CH2M HILL scope of work.

Subcontractor's _____ Date _____

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)

6. Rinse with 1 gallon of tap water.

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for much of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water-resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Sanford Sharpie® permanent markers.
2. On the inside cover of the log book the following information should be included:
    - Company name and address
    - Log-holders name if log book was assigned specifically to that person
    - Activity or location

- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."

4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.

5. Daily entries will be made chronologically.

6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.

7. Each page of the log book will have the date of the work and the note takers initials.

8. The final page of each day's notes will include the note-takers signature as well as the date.

9. Only information relevant to the subject project will be added to the log book.

10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.

2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified,

and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

- Description of the general sampling area – site name, buildings and streets in the area, etc.
- Station/Location identifier
- Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
- Sample matrix and type
- Sample date and time
- Sample identifier
- Draw a box around the sample ID so that it stands out in the field notes
- Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
- Number and type of sample containers collected
- Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
- Parameters to be analyzed for, if appropriate
- Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).

2. Use tables to record sampling information and field data from multiple samples.

3. Sketch sampling locations and other pertinent information.

4. Sketch well construction diagrams.

V. Attachments

Example field notes.

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project - CTO Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 08/21/12).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site). The field team should always follow the sample ID system prepared by the project EIS and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample

locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).

- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).

- Sign, date, and enter the time under "Relinquished by" entry.

- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.

- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.

- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.

- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

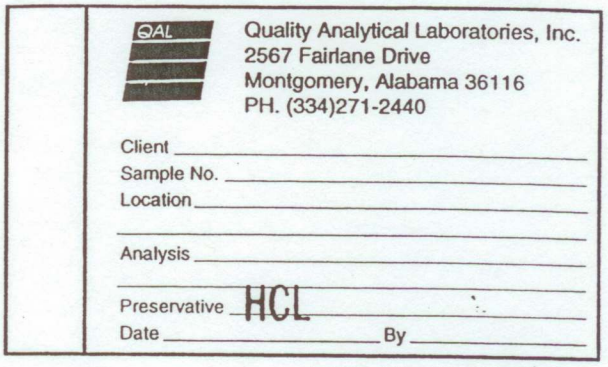
A. Sample Label
B. Chain of Custody Form
C. Custody Seal

VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A

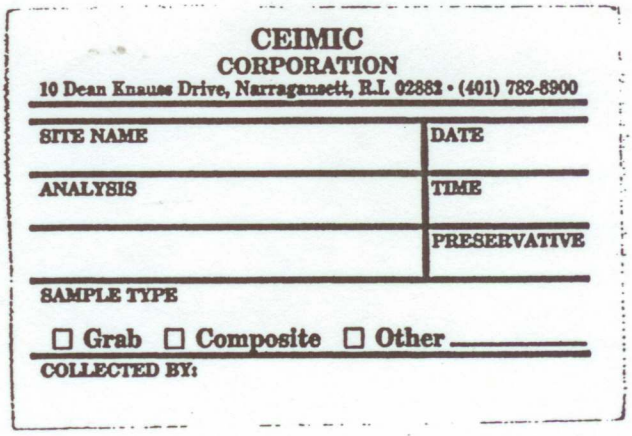
Example Sample Label



QAL

Quality Analytical Laboratories, Inc.
2567 Fairlane Drive
Montgomery, Alabama 36116
PH. (334)271-2440

Client _____
Sample No. _____
Location _____
_____
Analysis _____
_____
Preservative HCL
Date _____ By _____



CEIMIC
CORPORATION
10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE

SAMPLE TYPE

☐ Grab ☐ Composite ☐ Other _____

COLLECTED BY:

Attachment B

Example Chain-of-Custody Record

CH2M HILL

APPLIED SCIENCES LABORATORY

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project # ☐☐☐☐☐☐☐☐.☐☐.☐☐

Purchase Order #

Project Name

Company Name CH2M HILL Office

Project Manager & Phone #
Mr. [ ]
Ms. [ ]
Dr. [ ]

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

Sampling Date	Sampling Time	Type COMP	Type GRAB	Matrix WATER	Matrix SOIL	Matrix AIR	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA– FOR LAB USE ONLY

Lab 1 #

Lab 2 #

Quote #

Kit Request #

Project #

No. of Samples

Page of

Login

LIMS Ver

REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name) — Date/Time

Received By (Please sign and print name) — Date/Time

Received By (Please sign and print name) — Date/Time

Received By (Please sign and print name) — Date/Time

Work Authorized By (Please sign and print name)

Relinquished By (Please sign and print name) — Date/Time

Relinquished By (Please sign and print name) — Date/Time

Relinquished By (Please sign and print name) — Date/Time

Shipped Via UPS BUS Fed-Ex Hand Other ____

Shipping #

Remarks

QC Level: 1 2 3 Other: ____

COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

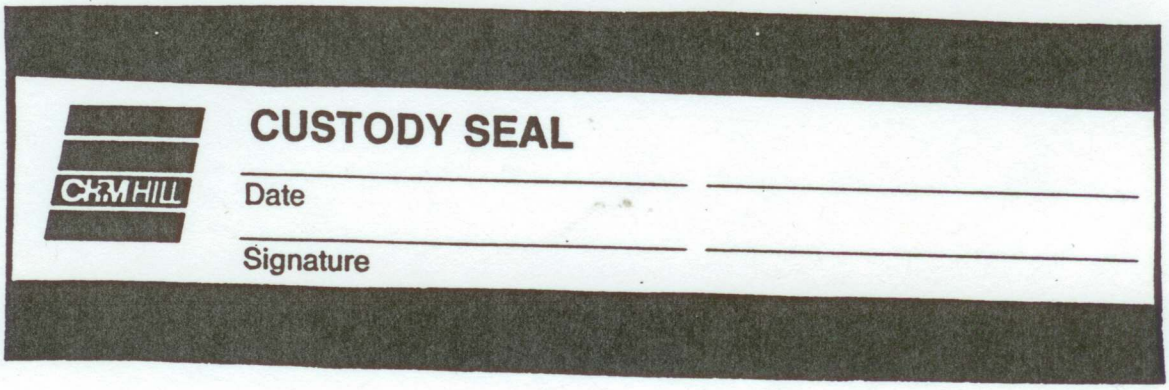
Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client

REV 3/94 FORM 340

Attachment C

Example Custody Seal


CRM HILL
CUSTODY SEAL
Date
Signature

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- "This Side Up" labels
- "Fragile" labels
- Vermiculite
- Ziplock bags or bubble wrap
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of vermiculite or absorbent pads.

B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.

C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.

D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.

G. Fill remaining spaces with vermiculite or absorbent pads.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with tape to avoid seals being able to be peeled from the cooler.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate vermiculite or other packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

Attachment 5
Laboratory SOPs

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE

FOR

THE DETERMINATION OF STRONTIUM 89/90 IN WATER, SOIL, MILK, FILTERS, VEGETATION AND TISSUES

(GL-RAD-A-004 REVISION 18)

APPLICABLE TO METHODS:
EPA 600/4-80-032 Method 905.0 (Modified)
DOE RP501 Revision 1 (Modified)
EML HASL-300 (Modified)

PROPRIETARY INFORMATION

GEL

GEL'S
DOCUMENT CONTROL OFFICER
CERTIFIES THIS DOCUMENT TO BE
A TRUE COPY OF THE FULLY
EXECUTED ORIGINAL.

AEJ

GEL Laboratories LLC
2040 Savage Road Charleston, SC 29407
P.O. Box 30712 Charleston, SC 2941
Main: 843.556.8171 Fax: 843.766.1178

TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF STRONTIUM 89/90 IN WATER, SOIL, MILK, FILTERS, VEGETATION, AND TISSUES 3
2.0 METHOD OBJECTIVE, PURPOSE, AND SUMMARY 3
3.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT 3
4.0 METHOD VARIATIONS 3
5.0 DEFINITIONS 3
6.0 INTERFERENCES 4
7.0 SAFETY PRECAUTIONS AND WARNINGS 5
8.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION 5
9.0 REAGENTS AND STANDARDS 5
10.0 SAMPLE HANDLING AND PRESERVATION 7
11.0 SAMPLE PREPARATION 7
12.0 QUALITY CONTROL SAMPLES AND REQUIREMENTS 17
13.0 INSTRUMENT CALIBRATION, STANDARDIZATION AND PERFORMANCE 17
14.0 PROCEDURE FOR ANALYSIS AND INSTRUMENT OPERATION 20
15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE 20
16.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS 20
17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL 20
18.0 RECORDS MANAGEMENT 20
19.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL 20
20.0 REFERENCES 20
21.0 HISTORY 21
APPENDIX 1 22
APPENDIX 2 23
APPENDIX 3 24
APPENDIX 4 25

1.0 STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF STRONTIUM 89/90 IN WATER, SOIL, MILK, FILTERS, VEGETATION, AND TISSUES

2.0 METHOD OBJECTIVE, PURPOSE, AND SUMMARY

2.1 This standard operating procedure provides the necessary instructions to conduct the analysis for isotopic Sr-89 and Sr-90 in water, soil, filters, vegetation, tissues, and milk.

2.2 This method has been modified from the source method EPA 600/4-80-032 "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," August 1980, Method 905.0, and uses the same principles of final source preparation, radiochemical concentration and counting. This method is also based on EML HASL-300, and is very similar in concept to the source method from the DOE Methods Manual for Evaluating Environmental and Waste Management samples, RP501, 1997 Edition, Revision 1.

2.3 This method has been modified on the basis of GEL's Performance Based Measurement System (PBMS).

3.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT

3.1 Method Detection Limit (MDL): Typical minimum detectable activity (MDA) for samples analyzed for Sr-89 and Sr-90 is 2 pCi/L or 2 pCi/g.

3.2 Analyst training records are maintained as quality records (refer to GL-QS-E-008). Analyst training and proficiency in the method is outlined in GL-QS-E-011 for Method Validation and Initial and Continuing Demonstrations of Capability.

4.0 METHOD VARIATIONS

Some variations may be necessary due to special matrices encountered in the lab. These variations may be used with approval from a Group Leader or Team Leader. Variations to a method will be documented with the analytical raw data.

5.0 DEFINITIONS

5.1 Batch: Environmental samples are prepared and/or analyzed together with the same process and personnel using the same lot(s) of reagents.

5.2 Deionized (DI) water: Type I Reagent water (Refer to GL-LB-E-016)

5.3 Laboratory Control Sample (LCS): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes from a source independent of the calibration standards or a material containing known and verified amounts of analytes.

5.4 Laboratory Duplicate (DUP): Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.

5.5 Matrix Spike (MS): Prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.

5.6 Matrix Spike Duplicate (MSD): A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

5.7 Method Blank (MB): A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples containing an analyte of interest through all steps of the analytical procedures.

5.8 National Institute of Standards and Technology (NIST): For the purpose of this method, the national scientific body responsible for the standardization and acceptability of analyte solutions.

5.9 Refer to SOP GL-QS-B-001 the Quality Assurance Plan for additional lab-wide used definitions.

6.0 INTERFERENCES

6.1 Breakthrough of strontium can occur after 45 free column volumes (FCVs)(1 FCV = 1.3 mL/column) pass through the column. To prevent breakthrough, the total volume (sum of sample loading plus rinses) passed through the column should be kept below 80% of the breakthrough volume.

6.2 Plutonium has been observed to retain up to 85% of the Sr Resin column under high acid conditions, which creates interferences in beta counting. This interference can be removed by passing the solution through a TRU Resin column at 2 to 6 M nitric acid. Plutonium is absorbed on the TRU Resin column; the strontium fraction elutes through the TRU Resin. The elution is then evaporated to dryness, re-dissolved in 8 M nitric acid, and passed through a Sr Resin column.

6.3 An excess of potassium-40 may also cause interference in subsequent beta counting due to retention of potassium on the Sr Resin column. This interference may be removed by the rinsing of the carbonate precipitate, as well as an additional 8 M nitric acid rinse on the Sr Resin column.

6.4 Stable strontium in the sample will compete for sites on the Sr Resin column and will affect chemical yields.

6.5 Ammonium ion interferes with milk. Sodium hydroxide is used instead of ammonium hydroxide to eliminate this interference.

6.6 Sr Resin, with 8 M nitric acid load and rinse solutions, is used to effectively remove barium-140 and potassium-40 isotopes as well as other matrix interferences. Tetravalent plutonium, neptunium, cerium, and ruthenium are not removed using nitric acid. These isotopes are effectively removed by including a rinse of 3 M nitric acid/0.05 M oxalic acid.

6.7 Milk fats tend to coat resin beads and clog ion exchange columns, so a batch process is used. Stable strontium is added to equilibrate the radiostrontium with the stable strontium carrier. Strontium is stripped from the resin with 8 M nitric

acid, converted to carbonate to concentrate the strontium, and separated from calcium and other elements by Sr Resin.

7.0 SAFETY PRECAUTIONS AND WARNINGS

7.1 Personnel performing this analytical procedure are trained to the safe laboratory practices outlined in the Safety, Health and Chemical Hygiene Plan, GL-LB-N-001.

7.2 Personnel handling radioactive materials are trained in and follow the procedures outlined in GL-RAD-S-004 for Radioactive Material Handling.

7.3 Personnel handling biological materials are trained in and follow the procedures outlined in GL-RAD-S-010 for The Handling of Biological Materials.

7.4 If there is any question regarding the safety of any laboratory practice, stop immediately, and consult qualified senior personnel such as a Group or Team Leader.

8.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION

8.1 Apparatus and Equipment

8.1.1 Stainless steel planchets (1” x 3/32")

8.1.2 Glass fiber filters

8.1.3 Hot plates

8.1.4 Centrifuge tubes (plastic)

8.1.5 Beakers (glass and Teflon of varying sizes)

8.1.6 Large glass chromatography columns

8.1.7 Drying lamps/drying oven

8.1.8 0.45 µm 25 mm diameter pre-weighed filter in disposable filter funnel

8.1.9 47 mm filter funnels

8.1.10 Sr Resin® columns EiChrom Industries Inc. or o2si equivalent

8.1.11 Teflon-coated stirring magnets

8.1.12 Petri dishes

8.1.13 2.5 cm^3 column

8.1.14 25 mL column funnel extension

8.1.15 Filtration apparatus

8.2 Instrumentation

8.2.1 Gas-flow proportional counting system

8.2.2 Analytical balance

9.0 REAGENTS AND STANDARDS

9.1 Reagents

9.1.1 Anion exchange resin, Analytical Grade 1X8, chloride form, 50-100 mesh and 100-200 mesh.

9.1.2 Ammonium hydroxide (NH_4OH), concentrated

9.1.3 50% Ammonium hydroxide solution: Slowly add 500 mL concentrated ammonium hydroxide to 500 mL DI water.

9.1.4 Calcium nitrate (1.25 M), calcium carrier: Dissolve 295 g of calcium nitrate tetrahydrate [$Ca(NO_3)_2 \cdot 4H_2O$] in 500 mL DI water and dilute to 1 L with DI water.

9.1.5 Cation resin, Marthon C, sodium form, or equivalent. Use 20-50 mesh material for easier recovery from the milk.

9.1.6 Deionized (DI) water

9.1.7 pH 10 DI water: Slowly adjust pH with 10 M sodium hydroxide.

9.1.8 80% Ethanol: Dilute 800 mL EtOH to 1 L with DI water.

9.1.9 Hydrochloric acid (HCl), concentrated, 12 M

9.1.10 Hydrochloric acid (HCl) 9 M: Add 750 mL concentrated HCl (12 M) to 250 mL of DI water.

9.1.11 Hydrofluoric acid (HF), concentrated

9.1.12 Hydrogen peroxide (30% H_2O_2)

9.1.13 Nitric acid (HNO_3), concentrated, 16 M

9.1.14 Nitric acid, 8 M: Add 500 mL concentrated nitric acid (16 M HNO_3) to 400 mL DI water, allow to cool, and dilute to 1000 mL with DI water.

9.1.15 3 M Nitric acid/0.05 M Oxalic acid solution: Carefully add 188 mL of concentrated HNO_3 (16 M) and add 6.3 g of oxalic acid dihydrate to 800 mL of DI water and dilute to 1 L with DI water.

9.1.16 Nitric acid, 2 M: Add 125 mL concentrated nitric acid (16 M HNO_3) to 500 mL DI water and dilute to 1000 mL with DI water.

9.1.17 Nitric acid, 0.05 M: Carefully mix 3.1 mL 16 M HNO_3 (concentrated) with 500 mL DI water and dilute to 1000 mL with DI water.

9.1.18 Methyl orange pH indicator

9.1.19 1 M Oxalic acid: Dissolve 126.07 g oxalic acid dihydrate in 500 mL DI water and dilute to 1000 mL.

9.1.20 Phenolphthalein solution

9.1.21 Sodium carbonate (Na_2CO_3), 0.75 M: Add 79.5 g Na_2CO_3 to 1000 mL with DI water.

9.1.22 Sodium hydroxide (NaOH), 6 M: Cautiously add 120 g NaOH pellets to approximately 300 mL water. When cool, dilute to 500 mL.

9.1.23 Sodium hydroxide (NaOH), 10 M. Add 400 g of NaOH pellets to 800 mL of DI water and mix. Dilute to 1 L when cool.

9.1.24 Strontium carrier (standardized), 10 mg/mL: Dissolve 24.16 g $Sr(NO_3)_2$ in DI water and dilute to 1000 mL. Alternatively use 10 Sr mg/mL o2si standard.

9.1.25 Thymol blue pH indicator

9.1.26 Yttrium carrier (standardized), 9 mg/mL: Add 11.43 g yttrium oxide (Y_2O_3) to a new beaker containing 20 mL DI water. Heat to boiling on a magnetic stirring hot plate while adding concentrated nitric acid in small amounts. Approximately 20 mL of concentrated nitric acid will be necessary to dissolve the yttrium oxide. Small additions of DI water may be required to replace what was lost by evaporation. After total dissolution, add 30 mL concentrated nitric acid and dilute to 1 L with DI water. Alternatively, use 10 Y mg/mL o2si standard.

9.2 Standards

Refer to GL-RAD-M-001 for instructions concerning the preparation of standard solutions.

9.2.1 NIST traceable Strontium-89 standard

9.2.2 NIST traceable Strontium-90 standard

10.0 SAMPLE HANDLING AND PRESERVATION

10.1 Water samples should be collected in plastic bottles and preserved with concentrated nitric acid to pH < 2.

10.2 Before beginning an analysis, the analyst should check the sample pH by removing a minimal amount of sample with a transfer pipette and placing the sample on a pH strip. **DO NOT** insert pH strip into sample container. If the sample is received with a pH greater than 2, the analyst should contact the Group Leader or Team Leader. If approved by the client, the analyst should adjust the pH with nitric acid to a pH < 2. If the sample is pH adjusted let the sample sit in the original container for a minimum of 24 hours before analysis.

10.3 Milk samples should be preserved with sodium bisulfate at approximately 40 grams/gallon, so that storage in a refrigerator is not necessary. Samples that are not preserved at collection must be kept refrigerated until preserved.

11.0 SAMPLE PREPARATION

NOTE: Sample aliquot size may be estimated using the count time estimator spread sheet.

NOTE: Spiking and tracing steps should be witnessed by either another analyst qualified in this procedure or the Team Leader/Group Leader responsible for this procedure. After

adding tracers and spikes, the witness must initial and record the date and time of witnessing.

11.1 Sample preparation techniques for water matrix.

11.1.1 Transfer an appropriate aliquot of water sample to a glass beaker and record the volume. If required, the DUP, and MS and MSD should be the same aliquot as the appropriate sample referenced. Prepare a MB and LCS by using DI water and concentrated nitric acid to a pH < 2. The MB and LCS volumes should be equivalent to the largest aliquot in the batch and should be recorded.

11.1.2 Add 0.5 mL of strontium carrier to each sample including MB and LCS. Add an appropriate amount of Sr-90 and/or Sr-89 spike to MS, LCS, and LCSD as applicable. Reference batch pull sheet for client requirements to determine appropriate spikes needed for the batch.

NOTE: Due to the short half life of Sr-89, if both Sr-89 and Sr-90 are being added as spikes, the volume to be added is determined by the decay corrected value in AlphaLIMS so that the dpm values for both isotopes are similar. If only adding Sr-90, then the typical volume added is 0.1 mL.

11.1.3 Add 3 to 4 drops of phenolphthalein solution, and then add 6 M NaOH dropwise until the sample turns a light pink color. Stir. Do not add NaOH in extreme excess.

11.1.4 Add 10 mL of 0.75 M sodium carbonate and stir.

NOTE: For samples that do not normally precipitate, add 2 to 3 mL of calcium carrier to all samples.

11.1.5 Cover the beaker with a watch glass and heat to rapid boiling.

11.1.6 Remove the watch glass and allow the precipitate to settle and cool for at least one hour, or overnight, if possible.

11.1.7 Aspirate the supernate then transfer the precipitate into a centrifuge tube using pH 10 DI water.

11.1.8 Centrifuge and discard the supernate.

11.1.9 Rinse the sides of the beaker with 15 mL 8 M nitric acid. Transfer the rinse to the centrifuge tube. This is the load solution for the Sr Resin column.

11.1.10 Proceed to Step 11.7, Strontium Determination.

11.2 Sample preparation techniques for soil matrix.

11.2.1 Leach method

11.2.1.1 Aliquot dried and homogenized sample into glass beaker. Record aliquot information. If required, the DUP, MS and MSD should be the same aliquot as the appropriate sample

referenced. Record the aliquot for the MB and LCS as the largest aliquot in the batch.

11.2.1.2 Add 0.5 mL of strontium carrier to each sample including MB and LCS. Add an appropriate amount of Sr-90 and/or Sr-89 spike to MS, MSD, LCS and LCSD as applicable. Reference batch pull sheet for client requirements to determine appropriate spike.

NOTE: Due to the short half life of Sr-89, if both Sr-89 and Sr-90 are being added as spikes, the volume to be added is determined by the decay corrected value in AlphaLIMS so that the dpm values for both isotopes are similar. If only adding Sr-90, then the typical volume added is 0.1 mL.

11.2.1.3 For sample aliquots > 0.5 g, it is recommended that the samples be ashed in a muffle furnace as specified in GL-RAD-A-021B.

11.2.1.4 Slowly add 20 to 50 mL of 8 M nitric acid to the beaker. Cover the sample with a watch glass and reflux, for approximately 30 minutes.

NOTE: When leaching concrete samples, concentrated nitric acid should be used instead of 8 M nitric acid due to the matrix of the sample.

11.2.1.5 Slowly add 2 to 3 drops of 30% hydrogen peroxide, swirl, and continue refluxing for approximately 30 minutes.

11.2.1.6 Repeat step 11.2.1.5 at least two more times.

11.2.1.7 Slurry the sample and transfer the mixture to a centrifuge tube.

11.2.1.8 Centrifuge the mixture to separate the leachate from the remaining soil. Transfer the leachate to a glass beaker.

11.2.1.9 Add 10 mL 8 M nitric acid to the centrifuge tube, cap and mix. Repeat Step 11.2.1.8.

11.2.1.10 Discard any remaining solid matter.

11.2.1.11 Heat the leached sample in the glass beaker to dryness on a hot plate.

11.2.1.12 Dissolve the residue in the glass beaker with 10 to 15 mL of 8 M nitric acid. Cover and reflux for approximately 15 minutes.

11.2.1.13 Remove samples from the hot plate and allow to cool. This is the load solution for the strontium column.

11.2.1.14 Proceed to Step 11.7, Strontium Determination

11.2.2 Preparation of large soil aliquots

11.2.2.1 Perform Steps 11.2.1.1 through 11.2.1.11 above.

11.2.2.2 Dissolve the sample residue from Step 11.2.1.11 in approximately 5 mLs of concentrated hydrochloric acid. Heat to dryness. Dissolve the sample residue in 10 to 15 mL of 9 M hydrochloric acid. This is the load solution for the anion exchange column.

11.2.2.3 Prepare the anion exchange column (large 7 cm columns) by filling the column to the top with anion exchange resin. Rinse the column with approximately 25 mL of 9 M hydrochloric acid.

11.2.2.4 Place a clean, labeled centrifuge tube under the anion column. Pass the sample through the anion column collecting it in the centrifuge tube.

11.2.2.5 Rinse the column with 15 to 20 mL of 9 M hydrochloric acid, and collect it in the centrifuge tube.

11.2.2.6 Take the volume in the centrifuge tube to dryness in a beaker on a hot plate.

11.2.2.7 Dissolve the residue in approximately 5 mL of concentrated nitric acid and evaporate to dryness. Dissolve the residue in the glass beaker with 10 to 15 mL of 8 M nitric acid. Cover and reflux for approximately 15 minutes.

11.2.2.8 Remove samples from the hot plate and allow to cool. This is the load solution for the strontium column.

11.2.2.9 Proceed to Step 11.7, Strontium Determination.

11.3 Sample preparation techniques for milk matrix.

11.3.1 Transfer appropriate aliquot of milk sample to a glass beaker and record volume. If required, the DUP, MS and MSD should be the same aliquot as the appropriate sample referenced. Prepare a MB and LCS by using DI water and concentrated nitric acid to a pH < 2. The MB and LCS volumes should be recorded.

11.3.2 Add 1.0 mL of strontium carrier to each sample including the MB and LCS. Add an appropriate amount of Sr-90 and/or Sr-89 spike to MS, MSD, LCS as applicable. Reference batch pull sheet for client requirements to determine appropriate spike.

NOTE: Due to the short half life of Sr-89, if both Sr-89 and Sr-90 are being added as spikes, the volume to be added is determined by the decay corrected

value in AlphaLIMS so that the dpm values for both isotopes are similar. If only adding Sr-90, then the typical volume added is 0.1 mL.

11.3.3 Add a Teflon-coated stirring magnet and stir for approximately 15 minutes.

11.3.4 Add 30 grams of Cation Exchange Resin Na^+ form, spherical beads (20-50 mesh), and continue stirring for at least one hour. Stirring must be vigorous enough to distribute the resin throughout the sample.

11.3.5 Remove the beaker from the stirrer and allow the resin to settle.

11.3.6 Slowly decant and discard the milk, ensuring that no resin is lost. Rinse the beaker with several (3 to 5) 600 mL portions of hot water, continuing until the rinse is clear. It is necessary that the milk be completely removed from the resin.

11.3.7 Transfer the resin to a large chromatography column that has been fitted with a control valve on the bottom. Allow the excess rinse water in the resin drain out. Discard the excess rinse water.

11.3.8 Place 1 liter beakers under columns. Elute the strontium from the resin by passing two 200 mL volumes of 8 M nitric acid through the column at a flow rate of 1 to 2 drops per second. Collect the effluent.

NOTE: If the flow rate exceeds 1 to 2 drops per second, the strontium will not be completely removed from the resin. Slower flow rates will not adversely affect the elution.

11.3.9 Evaporate the effluent to a volume of approximately 50 mL. Some insoluble material may be present. Dilute to at least 500 mL with DI water.

11.3.10 Add 3 to 4 drops of phenolphthalein solution, and then add 10 M sodium hydroxide until the sample turns a light pink color, stir.

11.3.11 Slowly add 50 mL of 0.75 M sodium carbonate while stirring.

11.3.12 Cover the beaker with a watch glass and heat to rapid boiling.

11.3.13 Remove the watch glass and allow the sample to cool for at least one hour, or overnight if possible, to allow all insoluble material to settle out.

11.3.14 Aspirate the supernate, and then transfer the voluminous precipitate into a centrifuge tube and centrifuge. Discard the supernate.

11.3.15 Wash the precipitate with approximately 35 mL of pH 10 DI water, ensuring that the precipitate is thoroughly re-suspended in the wash.

NOTE: This rinsing ensures removal of potassium prior to loading onto Sr column.

11.3.16 Centrifuge and discard supernate and repeat Step 11.3.15.

NOTE: Most milk contains 1400 to 1700 mg of potassium (K) per liter. Because the ionic radii of potassium and strontium are very close, potassium will compete with strontium for resin sites on the Sr resin. Therefore, removal of potassium is necessary to prevent extremely low strontium yields.

11.3.17 Discard supernate.

11.3.18 In small portions, very carefully add 20 to 30 mL of 8 M nitric acid until the precipitate is dissolved. Copious amounts of carbon dioxide will be evolved, and care must be taken to avoid loss of sample due to spattering.

11.3.19 Proceed to Step 11.7, Strontium Determination.

11.4 Preparation technique for air filters

11.4.1 Filters should be prepared in accordance with GL-RAD-A-026. Transfer an appropriate aliquot of the digested air filter to a glass beaker and record the volume. If required, the DUP, MS and MSD should be the same aliquot as the appropriate sample referenced. Prepare a MB and LCS by using DI water and concentrated nitric acid to a pH < 2. The MB and LCS volumes should be equivalent to the largest aliquot in the batch and should be recorded.

NOTE: If filter is not completely digested, consult TL or GL for additional instructions.

11.4.2 Add 0.5 mL of strontium carrier to each sample including MB and LCS. Add an appropriate amount of Sr-90 and/or Sr-89 spike to MS, MSD, LCS and LCSD as applicable. Reference batch pull sheet for client requirements to determine appropriate spike.

NOTE: Due to the short half life of Sr-89, if both Sr-89 and Sr-90 are being added as spikes, the volume to be added is determined by the decay corrected value in AlphaLIMS so that the dpm values for both isotopes are similar. If only adding Sr-90, then the typical volume added is 0.1 mL.

11.4.3 Add 3 to 4 drops of phenolphthalein solution, and then add 6 M sodium hydroxide dropwise while stirring until the sample turns a light pink color. Do not add NaOH in extreme excess.

11.4.4 Slowly add 10 mL of 0.75 M sodium carbonate.

11.4.5 Cover the beaker with a watch glass and heat to rapid boiling.

11.4.6 Remove the watch glass and allow the precipitate to settle and cool for at least one hour, or overnight if possible.

11.4.7 Aspirate the supernate, then transfer the precipitate into a centrifuge tube using pH 10 DI water.

11.4.8 Centrifuge and discard the supernate.

11.4.9 Rinse the sides of the beaker with 10-15 mL 8 M nitric acid. Transfer the rinse to the centrifuge tube. This is the load solution for the Sr Resin column.

11.4.10 Proceed to Step 11.7, Strontium Determination.

11.5 Preparation technique for tissue samples and vegetation.

11.5.1 Aliquot dried and homogenized sample into glass beaker for ashing. Record aliquot information. If required, the DUP, MS and MSD should be the same aliquot as the appropriate sample referenced. Record the aliquot for the MB and LCS as the largest aliquot in the batch.

11.5.2 Add 0.5 mL of strontium carrier to each sample including MB and LCS. Add an appropriate amount of Sr-90 and/or Sr-89 spike to MS, MSD, LCS and LCSD as applicable. Reference batch pull sheet for client requirements to determine appropriate spike.

NOTE: Due to the short half life of Sr-89, if both Sr-89 and Sr-90 are being added as spikes, the volume to be added is determined by the decay corrected value in AlphaLIMS so that the dpm values for both isotopes are similar. If only adding Sr-90, then the typical volume added is 0.1 mL.

11.5.3 Ash samples in accordance with GL-RAD-A-021B.

NOTE: Ashing of tissue and vegetation can take significantly longer than normal soils and the majority of sample should be gray or white when complete.

11.5.4 Once ashing is complete, add 300 mL of 8 M nitric acid and 1 mL of 1.25 M calcium nitrate.

11.5.5 Cover the sample and reflux for at least 1 to 2 hours. Allow to cool and filter through a glass fiber filter. Collect the filtrate.

11.5.6 Boil the filtrate and evaporate to approximately 25 to 50 mL. Dilute to approximately 700 mL with DI water.

11.5.7 Add 1 mL of methyl orange and 10 g of oxalic acid.

NOTE: For the above step, the 10 g of oxalic acid can be dissolved in 50 mL DI water and the dissolved solution added to the sample. Larger volumes of solution can be made in accordance to batch size.

11.5.8 Add ammonium hydroxide until the solution turns yellow, giving a pH of approximately 4. Allow the samples to sit overnight.

11.5.9 Aspirate the supernate and transfer the precipitate to a centrifuge tube. Centrifuge the sample and discard the supernate.

11.5.10 Rinse the precipitate with DI water and centrifuge. Discard supernate.

11.5.11 Dissolve the precipitate in 50 mL of 8 M nitric acid. Transfer to a 250 mL beaker and evaporate to dryness very slowly.

11.5.12 Wet ash the sample with 5 to 10 mL of concentrated nitric acid and 1 mL of hydrogen peroxide. (Repeat this step until the sample no longer produces a brownish gas.)

11.5.13 Evaporate to dryness.

11.5.14 Ash the samples in a furnace at approximately 500° C for at least 30 minutes. Allow the samples to cool.

11.5.15 Dissolve the sample residue with 15 mL of 8 M nitric acid and reflux on a hot plate until the solids dissolve. This is the load solution for the strontium column.

11.5.16 Proceed to Step 11.7, Strontium Determination.

11.6 Preparation technique for samples previously run and reported extremely high alpha Pu^{+4}, Np^{+4}, Ce^{+4}:

11.6.1 Pour aliquot. Spike appropriate samples.

11.6.2 Add 0.5 mL Sr carrier, 1 mL iron carrier, 5 mL concentrated nitric acid.

11.6.3 Reflux 1 hour. Add concentrated ammonium hydroxide in excess until iron precipitates. Centrifuge out the iron and keep the supernate.

11.6.4 Evaporate the sample to dryness and dissolve residue in approximately 10 mL of 2 M nitric acid. This is the load solution for Tru-spec columns.

11.6.5 Prepare Tru-Spec columns by rinsing with 10 mL of 2 M nitric acid.

11.6.6 Pour load solution through column and collect in centrifuge tube.

11.6.7 Pour sample back into beakers and evaporate to dryness. Dissolve residue in approximately 10 mL of 8 M nitric acid. This is the load solution for Sr columns. Proceed to step 11.7, Strontium Determination.

11.7 Strontium Determination

11.7.1 For each sample, prepare a 25 mm pre-weighed filter with funnel. Label each funnel and record the weight.

NOTE: For milk samples, large vegetation and tissue samples, use Sr columns with double the amount of Sr resin. Additionally, all rinse and eluent volumes must be doubled.

11.7.2 Condition the Sr Resin column by rinsing it with 5 mL if 8 nitric acid.

11.7.3 When the rinse has passed completely through the column, load the sample onto the column.

11.7.4 When the sample has passed completely through the column, rinse the tube with 5 to 10 mL of 8 M nitric acid, depending on sample color. (An additional 10 mL 8 M nitric acid rinse may be used to remove excess iron and potassium from the column.)

11.7.5 When the rinse has passed completely through the column, rinse the column with 10 mL of 3 M nitric acid/0.05 M oxalic acid. Discard the rinse.

11.7.6 When the rinse has passed completely through the column, rinse the column with 5 mL 8 M nitric acid.

NOTE: This additional 8 M rinse removes any residual oxalic acid and ensures full removal of K^{+} and Ba^{+2} that may be present.

11.7.7 When the rinse has passed completely through the column, place a clean labeled centrifuge tube under the column and elute the strontium with 15 mL of 0.05 M nitric acid. Record the date and time for the beginning of Y-90 in-growth as Sr separation. Save the labeled Sr Resin column for later Y-90 separation, if necessary.

11.7.7.1 If Sr-89 is required, add DI water to the column for preservation of the resin, then cap and save.

NOTE: The remaining steps should be performed as quickly as possible to avoid excess Y-90 growth. Y-90 in-grows at the rate of 1% an hour.

11.7.8 Add 2 drops of thymol blue indicator then add 6 M sodium hydroxide dropwise until the samples turn blue. Add 3 mL 0.75 M sodium carbonate and heat in the microwave until warm. Allow precipitate to settle for approximately 30 minutes.

11.7.8.1 After the strontium has been precipitated coming off of the Sr Resin column, if there is visibly too much precipitate, these steps can be taken:

11.7.8.1.1 Centrifuge the sample and decant the supernate.

11.7.8.1.2 Dissolve the precipitate in 15 to 20 mL concentrated nitric acid and allow to sit in a refrigerator overnight.

11.7.8.1.3 The next day centrifuge the sample and discard the supernate. (Should have strontium nitrate, $SrNO_3$.) Dissolve the precipitate in 8 M nitric acid and rerun through a Sr Resin column using the standard procedure.

11.7.9 Filter the samples through the pre-weighed filter rinsing the centrifuge tube with pH 10 DI water. Rinse the filter funnel with a minimum amount of pH 10 water. Rinse the filter funnel with minimum amount of 80% ethanol.

11.7.10 Allow filters to air dry in petri dishes. Weigh each filter and record the weight. Place the filter in a steel planchette and into the labeled petri

dish. Calculate the net weight on the filter to determine the strontium yield.

11.7.11 Turn filters and completed batch paperwork to count room for Gas Flow Proportional counting analysis.

11.8 Y-90 Isolation After In-growth

NOTE: If Sr-89 is known to be absent, or if total strontium is requested, the final result can be determined with a single count. However, if Sr-89 is present, Sr-90 is measured by isolating Y-90 using this section and counting the Y-90.

11.8.1 After total strontium has been determined, store the filters for a minimum of 5 to 7 days, to allow for Y-90 in-growth.

11.8.2 Remove the filter from the planchette and place in a labeled centrifuge tube with 10 mL of 8 M nitric acid. Shake well and allow the precipitate to completely dissolve. Remove the filter from the centrifuge tube using forceps. Rinse the filter into the centrifuge tube with approximately 5 mL of 8 M nitric acid. Condition column by adding 0.5 mL of yttrium carrier to each centrifuge tube and swirl.

11.8.3 For each sample, prepare a 25 mm pre-weighed filter with funnel and record the weight.

11.8.4 Recondition the same column used for the initial strontium separation by adding 5 mL of DI water into each column. Allow to drain. Condition column by adding 5 mL of 8 M nitric acid and allow to drain.

NOTE: The DI water removes Bi-210 in-growth from any Pb-210 that may be tightly bound to the resin.

11.8.5 Place a clean labeled centrifuge tube under each column. Load the sample into the column, rinse the centrifuge tube with 1 to 2 mL of 8 M nitric acid. Record the date and time as Y separation. This marks the end of the Y-90 in-growth and the start of the Y-90 decay.

11.8.6 When the sample has passed through the column, precipitate the yttrium by adding 1 drop of thymol blue indicator and 1 mL of 1 M oxalic acid. Add 2 mL concentrated ammonium hydroxide and swirl. Continue to precipitate samples by adding 50% ammonium hydroxide drop wise until samples reach a pH of 2.7. (This is indicated by a color change from pink to light orange, and checked with narrow range pH strips.) Allow the precipitate to settle for approximately 30 minutes. (Do not add ammonium hydroxide in excess.)

11.8.7 Swirl the centrifuge tube to mix the precipitate. Filter the sample through the pre-weighed filter, rinse the centrifuge tube and sides of the funnel with DI water. Rinse the filter funnel with 80% ethanol.

11.8.8 Allow filters to air dry in petri dish. Weigh each filter and record the weight. Place filter in steel planchette and into the labeled petri dish. Calculate the net weight on the filter to determine the yttrium yield.

11.8.9 Turn in samples and completed batch paperwork to the count room for gas flow proportional analysis.

12.0 QUALITY CONTROL SAMPLES AND REQUIREMENTS

NOTE: Client contractual QC requirements override the requirements in this section.

12.1 Analyst and Method Verification Requirements

Refer to GL-RAD-D-002 for instructions concerning the validation of analytical methods.

12.2 Method Specific Quality Control Requirements

12.2.1 A Method Blank (MB) should accompany each batch of 20 or fewer samples. The reported value of the blank should be less than or equal to the Contract Required Detection Limit (CRDL).

12.2.2 The carrier added to all samples is used to calculate the chemical yield. The chemical yield of all samples should be between 25-125%.

12.2.3 A Duplicate (DUP) sample should be run with each batch of 20 or less samples. The Relative Percent Difference (RPD) between the actual sample and the DUP should be less than or equal to 20% if both the sample and the DUP results are greater than 5 times MDC or 100% if they are both less than 5 times MDC. If both results are less than MDC then limits on RPD are not applicable.

12.2.4 A Laboratory Control Sample (LCS) should be run with each batch of 20 or less samples. The recovery of the LCS should fall between 75-125%.

12.3 Actions Required if the Quality Control Requirements Are Not Met

If any of the QC criteria cannot be satisfied, the analyst should inform the Group Leader and initiate a Data Exception Report as outlined in GL-QS-E-004.

13.0 INSTRUMENT CALIBRATION, STANDARDIZATION AND PERFORMANCE

13.1 Refer to appropriate counting procedure GL-RAD-I-006 or GL-RAD-I-016 for instrument calibration and performance.

13.2 Standardization of Sr carrier.

13.2.1 Pipet four aliquots (typically 1.0 mL) of strontium carrier (nom. conc. 10 mg Sr/mL) into tared 50 mL centrifuge tubes. Record the weight of each carrier aliquot.

13.2.2 Dilute to 30 mL with DI water. Add 2 drops of thymol blue indicator (or phenolphthalein). Add 6 M sodium hydroxide drop wise until the solution turns blue (or pink if using phenolphthalein). Add additional sodium hydroxide drop wise if necessary until the indicator changes

color. Add 5 mL of 0.75 M sodium carbonate to precipitate strontium carbonate. Heat in the microwave for approximately 20 to 30 seconds. Set aside for at least 15 minutes.

13.2.3 Filter through a pre-weighed tared Gooch crucible containing a double 2.1 cm glass fiber filter. Rinse with two 5 mL portions of pH 10 DI water, and one 5 mL portion of 80% alcohol.

13.2.4 Dry in the oven for approximately 30 minutes. Cool. Weigh.

13.2.5 Calculate the standard weight of strontium carrier in mg/mL of solution to obtain the standard weight for 1.00 mL of strontium carrier solution. Acceptable precision is a standard deviation of less than 1% of mean value. Record the carrier Reference Material number and the standardization results in the appropriate spreadsheet. Label the carrier solution with the standardization results.

13.3 Standardization of Y carrier.

13.3.1 Pipet four aliquots (typically 1.0 mL) of yttrium carrier (nom. conc. 9 mg Y/mL) into tared 50 mL centrifuge tubes. Record the weight of each carrier aliquot.

13.3.2 Dilute to 30 mL with water. Add 2 drops thymol blue indicator. Add 5 mL of 1 M oxalic acid. Add ammonium hydroxide drop wise until the indicator changes from pink to light orange.

NOTE: The desired pH is 2.7, which is necessary to ensure that yttrium oxalate precipitates with the correct stoichiometric form.

13.3.3 Heat in the microwave for approximately 20 to 30 seconds. Set aside for at least 15 minutes.

13.3.4 Filter through a pre-weighed tared Gooch crucible containing a double 2.1 cm glass fiber filter. Rinse with two 5 mL portions of DI water, and one 5 mL portion of 80% alcohol.

13.3.5 Dry in the oven for approximately 30 minutes. Cool. Weigh.

13.3.6 Calculate the standard weight of yttrium carrier in mg/mL of solution to obtain the standard weight for 1.00 mL of yttrium carrier solution. Acceptable precision is a standard deviation of less than 1% of mean value. Record the carrier Reference Material number and the standardization results in the appropriate spreadsheet. Label the carrier solution with the standardization results.

13.4 Preparation of Sr-89 Standards.

NOTE: Eppendorf pipets are used to quickly add estimated amount of carrier in the preparation of standards. To insure highest accuracy, the amount added is calculated by

weight. It is important to follow the filter preparation and precipitate washing and rinsing steps carefully to ensure highest accuracy in yield determination.

13.4.1 Weigh and record an aliquot of Sr-89 tracer (10,000 dpm) into a disposable centrifuge tube. Add varying amounts of Sr carrier into each tube. Record the information on the standard prep sheet.

13.4.2 Dilute to 30 mL with water and add 2 drops of thymol blue. Add 6 M sodium hydroxide drop wise until the sample turns blue. Do not add sodium hydroxide in excess. Then add 3 mL of 0.75 M sodium carbonate. Heat for approximately 20 to 30 seconds in the microwave, or at least 5 minutes in a hot water bath. Allow the precipitate to stand for at least 15 minutes.

13.4.3 Place a pre-weighed filter with filter cup into assembly, rinse the assembly with 5 mL of 80% ethanol, and connect the vacuum. Aspirate to dryness and disconnect vacuum. Swirl the centrifuge tube containing the standard to be filtered, and pour the entire sample into the filter reservoir. Apply and aspirate to dryness.

13.4.4 Disconnect vacuum. Rinse the filter with 5 mL of pH 10 DI water. Connect the vacuum and aspirate to dryness. (Repeat three times.)

13.4.5 Disconnect vacuum. Rinse the filter with 5 mL of 80% ethanol. Connect vacuum and aspirate to dryness. Continue to rinse funnel assembly with 80% ethanol as necessary to recover any precipitate clinging to walls.

13.4.6 With vacuum connected, remove the reservoir and rinse the edges of the filter with 80% ethanol. Disconnect vacuum and remove filter. Then allow filter to air dry.

13.4.7 Weigh filter to calculate yield and submit for counting.

13.5 Preparation of Y-90 and Sr-90 sources for instrument calibration.

NOTE: Calibration standards should be prepared without the use of vacuum boxes. Gravity flow rates are recommended.

13.5.1 Add a known amount of Sr-90 standard that has Y-90 in equilibrium to a centrifuge tube that contains 15 mL of 8 M nitric acid. Use an amount that will provide at least 10,000 counts measured on the detector in a short period of time.

13.5.2 Prepare a predetermined amount of Sr-Spec columns (usually 8) by pre-rinsing with 5 mL of 8 M nitric acid.

13.5.3 After the Sr-Spec column has drained completely, place a clean centrifuge tube under the column and transfer the contents of the centrifuge tube containing the load solution to the column. Record start time for yttrium-90 decay.

13.5.4 Rinse the centrifuge tubes with 2 mL of 8 M nitric acid and transfer to the Sr-Spec columns.

13.5.5 Add 5 mL 8 M nitric acid and allow to drain to the centrifuge tube.

13.5.6 Add 10 mL of 3 M nitric acid and allow to drain to the centrifuge tube.

13.5.7 Remove the centrifuge tube from under the columns and save for Y-90 precipitation. Place new centrifuge tubes under the columns.

13.5.8 Elute the Sr-90 from the column with 15 mL of 0.05 M nitric acid then rinse with a final 5 mL of 0.05 M nitric acid and combine the two elutions. Record this time as the Sr-90/Y-90 separation time.

13.5.9 Add varying amounts of stable strontium carrier to the strontium fractions and add 0.5 mL of stable yttrium carrier to the yttrium fractions.

13.5.10 Proceed to step 11.7.8 for strontium source preparation and to step 11.8.6 for yttrium source preparation. When source preparation is complete, the filters are ready for counting on the GFPC detectors.

14.0 PROCEDURE FOR ANALYSIS AND INSTRUMENT OPERATION

Refer to the appropriate counting procedure GL-RAD-I-006 or GL-RAD-I-016 for instrument operation.

15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

Refer to GL-RAD-I-010 for instrument maintenance.

16.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS

Data recording, calculation, and reduction take place in accordance with GL-RAD-D-003 and GL-RAD-D-006.

17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL

Data are reviewed and packaged in accordance with GL-RAD-D-003.

18.0 RECORDS MANAGEMENT

Records generated as a result of this procedure are maintained as quality documents in accordance with GL-QS-E-008 for Quality Records Management and Disposition.

19.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL

Radioactive samples and material shall be handled and disposed of as outlined in the Laboratory Waste Management Plan, GL-LB-G-001.

20.0 REFERENCES

20.1 B.D. Stewart, “Preparation of Milk Samples for Strontium Analysis,” Sr-01, Radiochemistry Procedures Manual, Arizona State University Radiation Measurements Facility, 1992.

20.2 DOE Methods for Evaluating Environmental and Waste Management Samples, RP501, 1997 Edition.

20.3 DOE EML Procedures Manual, HASL-300, 28th Edition, 1997.

20.4 Los Alamos National Laboratories Methods Manual.

20.5 Eichrom technical method data.

20.6 Special thanks to Dr. Frank Kinard with the College of Charleston for his help in reviewing the strontium method.

21.0 HISTORY

Revision 14: Updated the volume concentration of Nitric acid used in section 11.7.6. Inserted New NOTE: If excessive ammonium hydroxide was used during actinide scavenge then additional oxalic acid will need to ensure complete color change of indicator. Sample should be pink at this time.

Revision 15: Updated sections 13.2.5 and 13.3.6 to read acceptable precision is a standard deviation of less than 1% of the mean value.

Revision 16: Removed section regarding tandem analysis of APU/Sr and updated technical details of milk analysis.

Revision 17: Technical updates for SOP consistency as part of annual review.

Revision 18: Removed reference to Queue Sheets.

APPENDIX 1

STRONTIUM DETERMINATION

Use Sr resin column

Column Work

_____ 5 mL 8 M HNO_3 (conditioning)

_____ Load solution: 10 to 15 mL 8 M HNO_3

_____ Rinse 10 mL 8M HNO_3 (Additional 10 mL 8 M HNO_3 may be used to remove excess iron and potassium from column, if necessary)

_____ Rinse: 10 mL 3 M HNO_3/0.05 M Oxalic Acid

_____ Rinse: 5 mL 8 M HNO_3

_____ **Elute:** 15 mL 0.05 M HNO_3 and catch in a c-tube(Record date and time)

_____ Add 2 drops of Thymol Blue indicator and 6 M NaOH dropwise until blue

_____ Add 3 mL 0.75 M sodium carbonate and heat in microwave until warm

_____ Wait approximately 30 minutes

_____ Filter

APPENDIX 2

YTTRIUM ISOLATION AFTER IN-GROWTH

Use saved Sr Resin column from 1st separation

Column Work

_____ Rinse: 5 mL DI water

_____ Rinse: 5 mL 8 M HNO_3 conditioning

_____ Load: 8 M HNO_3 and catch in C-tube (Record date and time)

_____ Rinse: 1 to 2 mL 8 M HNO_3 and catch in C-tube

_____ To volume in C-tube, add 1 drop Thymol Blue and 1 mL 1 M Oxalic Acid

_____ Add 2 mL concentrated ammonium hydroxide and swirl

_____ Add 50% ammonium hydroxide dropwise until approximately pH 2.7

_____ Wait approximately 30 minutes

_____ Filter

APPENDIX 3

ANION EXCHANGE COLUMN FOR LARGE SOIL ALIQUOTS

Use 7 cm column with 1X8 anion exchange resin (Cl^- form 100-200 mesh)

Column Work:

_____ 25 mL 9 M HCl (conditioning)

_____ Load 9 M sample solution onto column and collect in C-tube

_____ Rinse with 15 to 20 mL 9 M HCl and collect in C-tube

_____ Take collected volume dry

_____ Dissolve residue in 8 M HNO_3 and allow to cool. This is the load solution for Sr determination (Appendix 1)

APPENDIX 4

STRONTIUM DETERMINATION FOR LARGE VEGETATION, TISSUE AND MILK

Use double Sr resin column

Column Work

_____ 10 mL 8 M HNO_3 (conditioning)

_____ Load solution: 20 to 25 mL 8 M HNO_3

_____ Rinse: 20 mL 8 M HNO_3

_____ Rinse with additional 20 mL 8 M HNO_3 to remove excess potassium from column

_____ Rinse: 20 mL 3 M HNO_3/0.05 M Oxalic Acid

_____ Rinse: 10 mL 8 M HNO_3

_____ **Elute:** 30 mL 0.05 M HNO_3 and catch in a c-tube (Record date and time)

_____ Add 2 drops of Thymol Blue indicator and 6 M NaOH dropwise until blue

_____ Add 3 mL 0.75 M sodium carbonate and heat in microwave until warm

_____ Wait approximately 30 minutes

_____ Filter

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE

FOR

THE ISOTOPIC DETERMINATION OF AMERICIUM, CURIUM, PLUTONIUM, AND URANIUM

(GL-RAD-A-011 REVISION 26)

APPLICABLE TO METHODS:
DOE RP800 1997 (Modified)
EML HASL-300 U-02-RC (Modified)
EML HASL-300 Am-05-RC (Modified)
DOE HASL-300 Pu-11-RC (Modified)
EPA SW-846 3050B (Modified)

PROPRIETARY INFORMATION

GEL

GEL'S
DOCUMENT CONTROL OFFICER
CERTIFIES THIS DOCUMENT TO BE
A TRUE COPY OF THE FULLY
EXECUTED ORIGINAL.

AEJ

GEL LABORATORIES LLC
2040 Savage Road Charleston SC 29407
P.O. Box 30712 Charleston, SC 29417
Main: 843.556.8171 Fax: 843.766.1178

TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR THE ISOTOPIC DETERMINATION OF AMERICIUM, CURIUM, PLUTONIUM, AND URANIUM 3
2.0 METHOD OBJECTIVE, PURPOSE, CODE, AND SUMMARY 3
3.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT 3
4.0 METHOD VARIATIONS 4
5.0 DEFINITIONS 4
6.0 INTERFERENCES 4
7.0 SAFETY PRECAUTIONS AND WARNINGS 5
8.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION 5
9.0 REAGENTS AND STANDARDS 6
10.0 SAMPLE HANDLING AND PRESERVATION 8
11.0 SAMPLE PREPARATION 8
12.0 QUALITY CONTROL REQUIREMENTS 16
13.0 INSTRUMENT CALIBRATION AND PERFORMANCE 17
14.0 ANALYSIS AND INSTRUMENT OPERATION 17
15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE 17
16.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS 17
17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL 17
18.0 RECORDS MANAGEMENT 17
19.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL 17
20.0 REFERENCES 17
21.0 HISTORY 18
APPENDIX 1 19
APPENDIX 2 20
APPENDIX 3 21
APPENDIX 4 22
APPENDIX 5 23
APPENDIX 6 24
APPENDIX 7 25

1.0 STANDARD OPERATING PROCEDURE FOR THE ISOTOPIC DETERMINATION OF AMERICIUM, CURIUM, PLUTONIUM, AND URANIUM

2.0 METHOD OBJECTIVE, PURPOSE, CODE, AND SUMMARY

2.1 This standard operating procedure provides the necessary instructions to conduct the analysis for isotopic americium, curium, plutonium, and uranium in a variety of liquid, filter and solid matrices. This method also gives specific guidance on determining U-232, Pu-242 and Am-243, which are typically used as isotopic tracers.

2.2 A soil sample is aliquoted and digested according to GL-RAD-A-015, if necessary. The elements are then separated through ion exchange resins. For liquid samples, transuranic elements are scavenged by coprecipitation with iron hydroxide. The precipitate is dissolved, and separation of elements is accomplished through ion exchange resins. The elements are then prepared for the measurement of radioactive isotopes by coprecipitation with neodymium fluoride. The neodymium fluoride precipitate is trapped on a filter, mounted on a metal disk and placed in a partially evacuated chamber for measurement of isotopic alpha emission.

2.3 This method has been modified from the source method from EML Methods Manual HASL-300 U-02-RC, Am-05-RC, and Pu-11-RC and uses similar principles of radiochemical separation and counting. Modifications include chemical separations utilizing Eichrom TEVA and TRU resins to facilitate separation of various elements. There are also variations in the concentrations of acids, as well as the application of these acids.

2.4 This method is also very similar in concept to the source method from the DOE Methods Manual for Evaluating Environmental and Waste Management Samples, 1997 Edition, RP800, “Sequential Separation of Americium and Plutonium by Extraction Chromatography.”

2.5 This method has been modified on the basis of GEL’s Performance Based Measurement System (PBMS).

2.6 This method also contains a special procedure for digestion of samples in accordance with EPA method SW-846 3050B (Modified).

3.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT

3.1 Method Detection Limit: Typical minimum detectable activity (MDA) for samples analyzed for Am/Cm/Pu/U is 1 pCi/L or 1 pCi/g for all isotopes.

3.2 Analyst training records are maintained as quality records as outlined in GL-QS-E-008. Analyst training and proficiency in the method is outlined in the Quality SOP for the Method Validation and Initial and Continuing Demonstrations of Capability, GL-QS-E-011.

3.3 Applicable matrices to this SOP are liquids, drinking water, vegetation, tissues, air filters, and solids.

NOTE: This method is not an EPA approved method for the analysis of drinking water.

4.0 METHOD VARIATIONS

Some variations may be necessary due to special matrices encountered in the lab. These variations may be used with approval from a Group or Team Leader. Variations to a method will be documented with the analytical raw data.

5.0 DEFINITIONS

5.1 AlphaLIMS: Laboratory Information Management System used at GEL.

5.2 Batch: Environmental samples prepared and/or analyzed together with the same process and personnel using the same lot(s) of reagents.

5.3 Deionized (DI) Water: Type I water, Refer to GL-LB-E-016.

5.4 Laboratory Control Sample (LCS): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes from a source independent of the calibration standards or a material containing known and verified amounts of analytes.

5.5 Laboratory Duplicate (DUP): Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.

5.6 Matrix Spike (MS): Prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.

5.7 Matrix Spike Duplicate (MSD): A second replicate matrix spike is prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

5.8 Method Blank (MB): A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples containing an analyte of interest through all steps of the analytical procedures.

5.9 National Institute of Standards and Technology (NIST): For the purpose of this method, the national scientific body responsible for the standardization and acceptability of analyte solutions.

5.10 Solid Reference Material (SRM): A solid material containing known and verified amounts of analytes.

5.11 Tracer: A known quantity of a radioisotope that is added to each sample of a chemically equivalent radioisotope of unknown concentration so that the yield of the chemical separation can be calculated.

6.0 INTERFERENCES

6.1 Internal tracer standards may have ingrown daughters that may interfere with the analysis. For example Th-228 will be present in aged U-232 standard, Fr-221 will be present in Th-229, which will interfere with the curium analysis, and U-232 will be present in Pu-236. These problems are overcome by running separate

aliquots of sample for thorium analysis, or by mathematical compensation for the interference.

6.2 Short lived radioactive progeny may ingrow on prepared filters. For example, the Ra-224 alpha peak will be present if the Th-228 parent is present. These interferences are minimized by counting sample as soon as possible after separation chemistry.

7.0 SAFETY PRECAUTIONS AND WARNINGS

7.1 Personnel performing this analytical procedure are trained in and follow the safe laboratory practices outlined in the Safety, Health and Chemical Hygiene Plan, GL-LB-N-001.

7.2 Personnel handling radioactive materials are trained in and follow the procedures outlined in GL-RAD-S-004 for Radioactive Material Handling.

7.3 Personnel handling biological materials are trained in and follow the procedures outlined in GL-RAD-S-010 for The Handling of Biological Materials.

7.4 If there is any regarding the safety of any laboratory practice, **stop immediately**, and consult qualified senior personnel such as a Group or Team Leader.

8.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION

8.1 Apparatus and Equipment

8.1.1 Silicon surface barrier detectors with associated electronics, vacuum chambers, and data reduction capabilities

8.1.2 Eichrom Technologies TEVA Resin, 100 – 150 µm particle size

8.1.3 Eichrom Technologies TRU Resin, 100 – 150 µm particle size

8.1.4 Vacuum pump and filtration apparatus

8.1.5 Disposable filter funnels (containing 25 mm polypropylene filters with 0.1 µm pore size)

8.1.6 Metal disks, 29 mm diameter

8.1.7 Stainless steel tweezers

8.1.8 Polypropylene centrifuge tube (50 mL)

8.1.9 Sample drying and ashing apparatus

8.1.10 Sample homogenization apparatus

8.1.11 AG 1X8 anion exchange resin, 100 – 200 mesh

8.1.12 Hot plate

8.1.13 Beakers (Glass and Teflon of various sizes)

8.1.14 2.5 cm^3 column

8.1.15 25 mL column funnel extension

8.1.16 Watch glasses (various sizes)

8.1.17 Digestion vessel

8.1.18 Reflux cap

8.1.19 Ribbed watch glass

8.1.20 Hot block

8.1.21 2.0 µm pore size plunger filter (PTF grade)

9.0 REAGENTS AND STANDARDS

9.1 Reagents

9.1.1 Neodymium carrier (500 mg/L)

9.1.2 Neodymium carrier (10,000 mg/L)

9.1.3 Carbon Colorant: Place four 47 mm cellulose nitrate filters in a beaker and add 5 mL concentrated sulfuric acid. Cover and heat on a hot plate with medium-high heat for approximately 2 to 4 hours. Cool dark residue completely. Slurry the residue in DI water and dilute to 1 L with DI water.

9.1.4 Hydrochloric acid (9 M HCl): Add 750 mL of concentrated hydrochloric acid to 100 mL of DI water. Allow to cool and dilute to 1 L with DI water.

9.1.5 Hydrochloric acid (3 M HCl): Add 250 mL of concentrated hydrochloric acid to 500 mL DI water. Allow to cool and dilute to 1 L with DI water.

9.1.6 Hydrochloric acid, concentrated (12 M HCl).

9.1.7 9 M Hydrochloric acid/0.05 M Ammonium iodide: Dissolve 7.24 g of ammonium iodide in 750 mL of concentrated hydrochloric acid and add to 100 mL of DI water. Allow to cool and dilute to 1 L with DI water. PREPARE DAILY.

9.1.8 Hydrochloric acid (6 M HCl): Add 500 mL of concentrated hydrochloric acid to 500 mL of DI water.

9.1.9 6 M Hydrochloric acid/0.52 M Hydrofluoric acid: Add 500 mL of concentrated hydrochloric acid and 18.6 mL of 49% hydrofluoric acid to 300 mL of DI water. Allow to cool and dilute to 1 L with DI water.

9.1.10 25% Hydrazine dihydrochloride: Dissolve 25 g of hydrazine dihydrochloride in 75 mL of DI water and dilute to 100 mL with DI water.

9.1.11 9 M Hydrochloric acid/0.04% Hydrogen peroxide: Add 8 drops of 30% hydrogen peroxide to 1 L of 9 M hydrochloric acid. PREPARE DAILY.

9.1.12 Ethyl alcohol (80% EtOH): Dilute 800 mL ethanol to 1 L with DI water.

9.1.13 Hydrochloric acid (0.1 M HCl): Add 8.3 mL of concentrated hydrochloric acid to 500 mL of DI water. Allow to cool and dilute to 1 L with DI water.

9.1.14 Hydrofluoric acid, concentrated (49% HF)

9.1.15 Hydrogen peroxide (30% H_2O_2)

9.1.16 Iron Carrier (10 mg/mL): Dissolve 62.7 g of $Fe(NO_3)_3 \bullet 6H_2O$ or 72.3 g of $Fe(NO_3)_3 \bullet 9H_2O$ in 800 mL DI water and dilute to 1 L with DI water.

9.1.17 Nitric acid concentrated (16 M HNO_3)

9.1.18 Nitric acid (2 M HNO_3): Add 125 mL of concentrated nitric acid to 500 mL of DI water. Allow to cool and dilute to 1 L with DI water.

9.1.19 Nitric acid (1 M HNO_3): Dilute 62.5 mL concentrated nitric acid to 500 mL of DI water. Allow to cool and dilute to 1 L with DI water.

9.1.20 2 M Nitric acid/1 M Aluminum nitrate: Dissolve 375.13 g of aluminum nitrate nonahydrate, $Al(NO_3)_3 \bullet 9H_2O$, in 300 mL of DI water. Add 125 mL of concentrated nitric acid to the DI water. Allow to cool and dilute to 1 L with DI water.

9.1.21 Titanium (III) chloride, 10-20% reagent

9.1.22 Hydrochloric acid (2 M HCl): Add 167 mL of concentrated hydrochloric acid to 500 mL DI water. Allow to cool and dilute to 1 L with DI water.

9.1.23 Nitric acid (1 M HNO_3): Add 62.5 mL of concentrated nitric acid to 500 mL of DI water. Allow to cool and dilute to 1 L with DI water.

9.1.24 1.25 M Calcium nitrate: Dissolve 205 g of anhydrous calcium nitrate or 295 g hydrated calcium nitrate, $Ca(NO_3)_2 \bullet 4H_2O$, in 500 mL of DI water. Dilute to 1L with DI water.

9.1.25 Phosphoric acid, concentrated (H_3PO_4)

9.1.26 Lanthanum (10,000 mg/L)

9.1.27 Sulfuric acid (0.1 M H_2SO_4): Add 5 mL concentrated sulfuric acid to 800 mL of DI water. Allow to cool and dilute to 900 mL.

9.1.28 Formic acid, concentrated

9.1.29 4 M Ammonium thiocyanate/0.1 M Formic acid: Add 60 g of ammonium thiocyanate and 1.0 mL of concentrated formic acid to a graduated cylinder and dilute to 200 mL with DI water. Prepare fresh daily.

9.1.30 1.5 M Ammonium thiocyanate/0.1 M Formic acid: Add 9.5 g of Ammonium thiocyanate and 0.5 mL of concentrated formic acid to a graduated cylinder and dilute to 100 mL with DI water. Prepare fresh daily.

9.1.31 Substrate suspension: Dilute 4 mL of neodymium chloride (10,000 mg/L), 80 mL of concentrated hydrochloric acid and 40 mL of carbon colorant to 1500 mL with DI water. Add 40 mL 49% hydrofluoric acid while swirling and dilute to 2 L with DI water.

9.1.32 Sulfuric acid, concentrated (18 M H_2SO_4).

9.1.33 Cellulose nitrate filters (47 mm)

9.1.34 Ammonium hydroxide concentrated (14 N NH_4OH)

9.1.35 Acetone

9.2 Standards

9.2.1 NIST traceable standards: Am-241, Am-243, Cm-244, Pu-242, Pu-239, Pu-238, Pu-236, U-232, U-236, U-238.

9.2.2 Refer to GL-RAD-M-001.

10.0 SAMPLE HANDLING AND PRESERVATION

10.1 Samples should be collected in a plastic bottle and preserved to approximately pH< 2 with nitric acid.

10.2 Before beginning an analysis, the analyst should check the sample pH by removing a minimal amount of sample with a transfer pipette and placing it on a pH strip. DO NOT insert pH strip into sample container. If the sample is received with a pH greater than 2, the analyst should contact the Group Leader or Team Leader. If approved by the client, the analyst should adjust the pH with nitric acid to a pH< 2. If the sample pH is adjusted, let the sample sit in the original container for a minimum of 24 hours before analysis. This acidification should be documented on a batch history sheet and attached to the batch paper work.

10.3 If the sample has exceeded the hold time the analyst should contact the Group Leader before continuing with the batch.

10.4 Soil and filter matrices require no preservation and may be shipped in any suitable container.

11.0 SAMPLE PREPARATION

NOTE: Aliquots may be estimated by using the count time estimator spreadsheet.

11.1 Soil Sample Preparation:

11.1.1 If not already done, dry and homogenize the sample by performing GL-RAD-A-021.

11.1.2 Measure an appropriate aliquot of soil (usually 0.2 g to 1.0 g) in a glass container or digestion vessel. If required, the DUP, MS and MSD should be the same aliquot as the appropriate sample referenced on the Queue sheet. Record all aliquots on the Queue sheet. Add approximately 4 to 6 drops of iron carrier to the Blank and LCS beakers. The Blank and LCS aliquot should be recorded on the Queue sheet to be the same aliquot as the largest sample in the batch. For soils and other special matrices, such as vegetation, air filters, tissue, etc., Deionized water is a suitable matrix for use as the MB and LCS aliquot. Iron carrier may also be added to all samples in the batch, if necessary, based on the appearance and iron content of each sample. If Solid Reference Material is required, weigh out approximately 0.1 g into the LCS beaker and record the exact weight on the Queue sheet.

11.1.3 Add a certified dpm of the appropriate tracer to each of the samples (usually between 5 to 10 dpm). Add a certified dpm (usually between 5 to 10 dpm) of the appropriate spike to the MS, MSD, LCS and LCSD as applicable. Reference batch Queue sheet and pull sheet for client requirements to determine appropriate tracer and spike.

11.1.3.1 For the determination of isotopic americium/curium, Am-243 is typically used as the tracer, and Am-241/Cm-244 are typically used as the spike.

11.1.3.2 For the determination of isotopic plutonium, Pu-242 is typically used as the tracer and Pu-239 is typically used as the spike. Pu-236 is an acceptable tracer provided no significant impurities are present.

NOTE: If Pu-241 is run in tandem, a separate MS and LCS is required to quantify Pu-241 spike recovery.

11.1.3.3 For the determination of isotopic uranium, U-232 is typically used as the tracer, and U-238 is typically used as the spike.

NOTE: The addition of tracers and spikes should be witnessed by either another analyst qualified on this procedure, a Team Leader or a Group Leader. After adding the tracers and spikes, the witness must initial and record the date of witnessing on the Queue sheet.

11.1.3.4 When running samples sequentially with Sr, all Sr carriers and spikes should be added prior to leach or digestion. See step 11.10.2 regarding collection procedures for Sr analysis.

11.1.4 If the analysis of the sample calls for quantification of U-232, Pu-242 or Am-243, the following steps shall be taken:

11.1.4.1 The sample will be run normally with the tracer indicated in sections 11.1.3 or 11.2.2.

11.1.4.2 A second run of the sample shall be made with a different tracer isotope such as U-236, Pu-236 or Cm-244. The quantification of the isotope that was normally the tracer can then be made. If there is any quantifiable activity a correction can be made to the initial run by calculating a correction ratio for the tracer recovery of the first run from the second run results.

NOTE: If prescribed to analyze by EPA method 3050B (Modified), proceed Appendix 7.

11.1.5 It is recommended that the samples be ashed in a muffle furnace as specified in GL-RAD-A-021B.

11.1.6 For uranium analysis, digest aliquot as specified in GL-RAD-A-015 and proceed to step 11.2.8.

11.1.7 A separate Am/Cm/Pu aliquot is treated with an aggressive acid leach of 6M or 9M hydrochloric acid depending on matrix and sample aliquot as described in the following steps. Uranium should not be run by this leaching technique.

NOTE: Determining the leaching routine is based on analyst experience with the matrix. The concentration required to obtain the leached sample will vary depending on the type of material, size of aliquot, muffling of sample, and other factors. The influence of these factors generally can be established by good judgment and experience with the materials being tested.

11.1.7.1 Place the sample in a beaker and add approximately 10 to 20mL of appropriate hydrochloric acid concentration per gram of sample with a minimum of 10 mL.

11.1.7.2 Heat the samples on medium heat and cover with a watch glass. Allow to leach for a minimum of 2 hours. Agitate the sample periodically to enhance the leaching process.

11.1.7.3 Allow the sample to partially cool and transfer to a centrifuge tube. Centrifuge the sample to separate the solid and leached portions.

11.1.7.4 Decant the leachate to a clean labeled beaker, and rinse the solid phase with DI water. Centrifuge the sample and decant the leachate into the beaker.

11.1.7.5 Evaporate the solution to dryness on medium heat.

11.1.7.6 Proceed to step 11.2.8.

11.2 Aqueous Sample Preparation:

11.2.1 Add an appropriate aliquot of sample to a labeled beaker. Prepare a Blank and LCS using DI water and a small amount of concentrated nitric acid to a pH < 2. The volume of DI water used should be the same as the largest volume of sample in the batch. If required, the DUP, MS and MSD should be the same aliquot as the appropriate sample referenced on the Queue sheet. Record all aliquots on the Queue sheets.

11.2.2 Add a certified dpm of the appropriate tracer to each of the samples (usually between 5 to 10 dpm). Add a certified dpm (usually between 5 to 10 dpm) of the appropriate spike to the MS, MSD, LCS and LCSD as applicable. Reference batch Queue sheet and pull sheet for client requirements to determine appropriate tracer and spike.

11.2.2.1 For the determination of isotopic americium/curium, Am-243 is typically used as the tracer, and Am-241/Cm-244 are typically used as the spike.

11.2.2.2 For the determination of isotopic plutonium, Pu-242 is typically used as the tracer, and Pu-239 is typically used as the spike. Pu-

236 is an acceptable tracer, provided no significant impurities are present.

NOTE: If Pu-241 is run in tandem, a separate MS and LCS is required to quantify Pu-241 spike recovery.

11.2.2.3 For the determination of isotopic uranium, U-232 is typically used as the tracer, and U-238 is typically used as the spike.

11.2.2.4 When running samples sequentially with Sr, all Sr carriers and spikes should be added prior to initial iron precipitation to scavenge actinides. See section 11.10 regarding collection procedures for Sr analysis.

NOTE: The addition of tracers and spikes should be witnessed by either another analyst qualified on this procedure, a Team Leader or a Group Leader. After adding the tracers and spikes, the witness must initial and record the date of witnessing on the Queue sheet.

11.2.3 If the analysis of the sample calls for quantification of U-232, Pu-242 or Am-243, the following steps shall be taken:

11.2.3.1 The sample will be run normally with the tracer indicated in sections 11.1.3 or 11.2.2.

11.2.3.2 A second run of the sample shall be made with a different tracer isotope such as U-236, Pu-236 or Cm-244. The quantification of the isotope that was normally the tracer can then be made. If there is any quantifiable activity a correction can be made to the initial run by calculating a correction ratio for the tracer recovery of the first run from the second run results.

11.2.4 If samples contain large amounts of sediment that the client requires analyzed with the liquid portion of the sample, proceed to step 11.9.

NOTE: Other sample matrices, such as vegetation, air filters, tissue, etc. are prepared as outlined in GL-RAD-A-026. The analyst must ensure that the appropriate tracer(s) are added to these other matrices as discussed in sections 11.1.3 or 11.2.2.

11.2.5 Add 1 mL of iron carrier (10 mg/mL).

11.2.6 Add concentrated ammonium hydroxide until turbidity persists, or pH > 9. Then add approximately 2 mL in excess. Heat to boiling for approximately 10 minutes or until precipitate breaks into fine particles. Allow to settle and cool.

11.2.7 Decant excess supernate and discard. Collect the remaining precipitate by centrifugation in a 50 mL centrifuge tube and discard the supernate.

NOTE: Exercise care in this step because finely divided material that contains the actinides may also be present in addition to the large iron hydroxide flocks.

11.2.8 Dissolve the precipitate from step 11.2.7 or residue from step 11.1.6 or 11.1.7.5 in 10 to 15 mL of 9 M hydrochloric acid /0.04% hydrogen peroxide solution.

NOTE: Samples may be dissolved with 10 to 15 mL of 9 M hydrochloric acid and then add 1 drop of 30% hydrogen peroxide as an alternative to dissolving with 9 M hydrochloric acid /0.04% hydrogen peroxide. This may also be done by dissolving samples with 10 to 15 mL 9 M hydrochloric acid and adding approximately 1 mL of DI water to approximately 1 mL of 30% hydrogen peroxide, mixing and adding one drop to each sample.

NOTE: If uranium only is required, the load solution is 10 to 15 mL of 9 M hydrochloric acid.

11.2.9 Slurry AG 1x8 anion resin (Cl form 100-200 mesh) in a squirt bottle with DI water. Transfer the resin to a small column to obtain a settled resin bed of approximately 2.5 mL.

11.2.10 Condition the column with 10 mL of 9 M hydrochloric acid.

11.2.11 Pass the sample solution from step 11.2.8 through the column and collect the eluate in a labeled, disposable 50 mL centrifuge tube for americium/curium analysis.

11.2.12 Rinse the column with 5 mL of 9 M hydrochloric acid and collect with the americium/curium fraction. Proceed to step 11.3.

11.2.13 Rinse the column with an additional 15 mL of 9 M hydrochloric acid and collect in a drip pan for disposal.

11.2.14 Elute plutonium by adding 10 mL of 9 M hydrochloric acid /0.05 M ammonium iodide solution, catching the plutonium elution in a labeled, disposable 50 mL centrifuge tube. Proceed to step 11.5 for plutonium microprecipitation for alpha spectroscopy. This elution may be omitted if plutonium analysis is not required.

11.2.15 Rinse the column with 15 mL of 6 M hydrochloric acid /0.52 M hydrofluoric acid and collect in a drip pan for disposal.

11.2.16 Rinse the column with 5 mL of 6 M hydrochloric acid and collect in a drip pan for disposal.

11.2.17 Place a labeled, disposable 50 mL centrifuge tube under each column. Elute uranium from the column using 15 mL of 0.1 M hydrochloric acid. Proceed to step 11.6 for uranium microprecipitation for alpha spectroscopy.

11.3 Americium/Curium Separation via TRU Resin:

NOTE: If sample aliquot is small or liquid sample is clean and free of particulates continue with step 11.3.1 and TRU column work. If not, proceed to step 11.3.5 for additional clean-up steps and TRU column work.

11.3.1 Precondition a 2 mL TRU column with 5 mL of 9 M hydrochloric acid.

11.3.2 Pass the sample solution from step 11.2.12 through the column collecting in a drip pan for disposal.

11.3.3 Rinse the column with 5 mL of 9 M hydrochloric acid collecting in a drip pan for disposal.

11.3.4 Place a labeled, disposable 50 mL centrifuge tube under each column. Elute americium and curium from the column using 20 mL of 3 M hydrochloric acid. Proceed to step 11.4 Americium/Curium microprecipitation for alpha spectroscopy.

11.3.5 Add 0.5 mL of 1.25 M calcium nitrate to the elution from step 11.2.12.

11.3.6 Add 1.0 mL of phosphoric acid. Swirl to mix.

11.3.7 Dilute to approximately 30 mL with DI water.

11.3.8 Add 28-30% ammonium hydroxide to pH of 8 to 10 to precipitate calcium phosphate. Do not over precipitate.

11.3.9 Allow to cool then spin samples in a centrifuge and pour off supernate.

11.3.10 Add approximately 25 mL of DI water to centrifuge tube, cap, and shake vigorously to break up precipitate.

11.3.11 Spin samples in a centrifuge and pour off supernate.

11.3.12 Add 15 mL of 2 M nitric acid/1 M aluminum nitrate to centrifuge tube and dissolve precipitate. Gently heat if necessary. Solution should be clear.

11.3.13 Precondition a 2 mL TRU column with 10 mL of 2 M nitric acid, collecting the rinse in a drip pan for disposal.

11.3.14 Pass the sample solution from step 11.3.12 through the column, collecting the load solution in a drip pan for disposal.

11.3.15 Rinse the column twice with 5 mL of 2 M nitric acid and collect the rinse in a drip pan for disposal.

11.3.16 Rinse the column with 5 mL of 1 M nitric acid and collect the rinse in a drip pan for disposal.

11.3.17 Place a labeled, disposable 50 mL centrifuge tube under each column. Elute americium and curium from the column using 20 mL of 3 M hydrochloric acid. If rare earth elements are suspected in the sample proceed to step 11.8.1 to separate rare earth elements via TEVA resin, otherwise, continue with step 11.4.

11.4 Americium/Curium Microprecipitation:

11.4.1 Dilute americium elution from step 11.3.4, 11.3.17, or 11.8.11 to approximately 40 mL with DI water. Add 0.1 mL of neodymium carrier (500 mg/L) to the solution and swirl to mix. Add 5 mL of 49% hydrofluoric acid and swirl to precipitate fluorides. Allow solution to sit for approximately 30 minutes, then proceed to step 11.7.1.

11.5 Plutonium Microprecipitation

11.5.1 Dilute plutonium elution from step 11.2.14 to approximately 40 mL with DI water. Add 0.1 mL of neodymium carrier (500 mg/L) and swirl. Add approximately 3 to 4 drops of 25% hydrazine dihydrochloride and swirl to mix. Let the solution sit for approximately 10 minutes, and add 5 mL of 49% hydrofluoric acid. Swirl to mix. Allow solution to sit for approximately 30 minutes, then proceed to step 11.7.1.

11.6 Uranium Microprecipitation:

11.6.1 Dilute uranium elution from step 11.2.17 to approximately 40 mL with DI water. Add 0.1 mL of neodymium carrier solution (500 mg/L) and swirl to mix. Add 0.5 mL of titanium (III) chloride solution and allow the sample to sit for approximately 30 seconds. Add 5 mL of 49% hydrofluoric acid to precipitate fluorides. Allow the solution to sit for approximately 30 minutes, then proceed to step 11.7.1.

11.7 Sample Filtration:

11.7.1 Place a disposable filter funnel on the filter support screen. Wet the filter with 80% ethyl alcohol and apply vacuum.

11.7.2 Add 5 mL of substrate suspension. After solution has passed through filter, add another 5 mL of substrate suspension.

11.7.3 Add 1 mL of the carbon colorant.

11.7.4 Filter the fluoride precipitated solution through the filter paper. Rinse the centrifuge tube with approximately 5 mL DI water and pass through filter.

11.7.5 Rinse the funnel with 80% ethyl alcohol.

CAUTION: Directing a stream of liquid onto the filter will disturb the distribution of the precipitate on the filter and render the sample unsuitable for alpha spectrometry resolution.

11.7.6 Without turning off the vacuum, remove the funnel.

11.7.7 Turn off vacuum and remove filter. Mount filter on a labeled 29 mm flat planchet. Ensure that the filter is centered and as flat as possible on the planchet.

NOTE: Care should be taken not to touch the active area of the filter with tweezers.

11.7.8 Place the mounted filter under a heat lamp for approximately 5 minutes or allow to air dry completely prior to alpha spectrometry measurement.

11.7.9 Submit samples for Alpha Spec counting.

NOTE: After Alpha Spec counting and review is complete, if Pu-241 analysis is required, proceed to SOP GL-RAD-A-035 step 11.2.31.

11.8 Separation of Americium from the Rare Earth Elements via TEVA Resin:

11.8.1 Transfer the elution from Step 11.3.17 to a clean beaker and add 0.3 mL of lanthanum. Gently cook dry on low heat.

11.8.2 Once the samples have cooled, add 5 mL of concentrated nitric acid and approximately 2 mL of 30% hydrogen peroxide. Heat on a hot plate at low heat to dryness. Cool and repeat.

11.8.3 Dissolve residue in approximately 1 ml of 0.1 M sulfuric acid. Evaporate until a very small amount of acid remains.

11.8.4 Dissolve residue in approximately 1 mL of concentrated formic acid. Evaporate until a very small amount of acid remains.

11.8.5 Repeat step 11.8.4, and evaporate the sample under low heat until the beaker is gently dry.

11.8.6 Dissolve the sample in 10 mL of 4 M ammonium thiocyanate/0.1 M formic acid. Be sure that the 4 M ammonium thiocyanate/0.1 M formic acid is prepared fresh daily.

11.8.7 Condition a TEVA column with 5 mL of 4 M ammonium thiocyanate/0.1 M formic acid, collecting the rinse in a drip pan for disposal.

11.8.8 Load the sample onto the TEVA column, collecting the load in a drip pan for disposal.

11.8.9 Rinse the beaker with 5 mL of 4 M ammonium thiocyanate/0.1 M formic acid and add to the column, collecting the rinse in a drip pan for disposal.

11.8.10 Rinse lanthanum and other rare earth elements from the column with 10 mL of 1.5 M ammonium thiocyanate/0.1 formic acid, collecting the rinse in a drip pan for disposal. Be sure that the 1.5 M ammonium thiocyanate/0.1 formic acid is prepared fresh daily.

11.8.11 Place a labeled, disposable 50 mL centrifuge tube under each column. Elute americium with 20 mL of 2 M hydrochloric acid.

11.8.12 Proceed to Step 11.4 to precipitate and filter samples.

11.9 Samples Containing Large Amounts of Sediment

NOTE: When aliquoting samples that contain large amounts of sediment, ensure that the sample is thoroughly homogenized.

11.9.1 Evaporate to dryness on medium to low heat.

11.9.2 Muffle in a furnace at approximately 550˚ C for a minimum of 2 hours.

11.9.3 If uranium analysis is required, leach for approximately 30 minutes and proceed to step 11.1.6.

11.9.4 If americium, curium, or plutonium analyses are required, proceed to step 11.1.7.

NOTE: Samples requiring americium extraction MUST be separated from rare earth elements via TEVA resin.

11.10 Preparation technique for Sr samples run in tandem with americium, plutonium, or uranium analysis.

11.10.1 Supernate from step 11.2.7 should be decanted into a clean, labeled beaker for further Sr analysis. Do not discard.

11.10.2 Elution from steps 11.2.11 and 11.2.12 should be collected in a clean, labeled centrifuge tube.

11.10.3 If americium/curium analysis is not required sample should be combined with supernate from step 11.10.1. Then proceed to appropriate SOP for Sr analysis.

11.10.4 If americium/curium analysis is needed proceed to step 11.3. Elution from steps 11.3.2 and 11.3.3 should be collected in a clean, labeled centrifuge tube. Elution should be combined with supernate from step 11.10.1. Then proceed to appropriate SOP for Sr analysis.

12.0 QUALITY CONTROL REQUIREMENTS

NOTE: Client contractual QC requirements override the requirements in this section.

12.1 Analyst and Method Verification Requirements

Refer to GL-RAD-D-002 for instructions concerning the validation of analytical methods.

12.2 Method Specific Quality Requirements

12.2.1 A method blank (MB) should accompany each batch of 20 or less samples. The reported value of the blank should be less than or equal to the contract required detection limit (CRDL).

12.2.2 The tracer added to all samples is used to calculate the method recovery. The method recovery of all samples should be between 15-125% when compared to the reference standard.

12.2.3 A duplicate (DUP) sample should be run with each batch of 20 or less samples. The relative percent difference (RPD) between the actual sample and the DUP should be less than or equal to 20% if both the sample and DUP results are greater than 5 times the minimal detectable concentration (MDC), or 100% if they are both less than 5 times MDC. If both results are less than the MDC, then limits are not applicable.

12.2.4 A laboratory control sample (LCS) should be run with each batch of 20 or less samples. The recovery of the LCS should fall between 75-125%.

12.3 Actions Required if the Quality Control Requirements Are Not Met

If any of the QC criteria from 12.2.1 through 12.2.4 cannot be satisfied, the analyst should inform the Group Leader and initiate a Data Exception Report (DER) as outlined in GL-QS-E-004.

13.0 INSTRUMENT CALIBRATION AND PERFORMANCE

For direction on calibration and instrument performance refer to GL-RAD-I-009.

14.0 ANALYSIS AND INSTRUMENT OPERATION

For analysis and instrument operation refer to GL-RAD-I-009.

15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

For maintenance of system refer to GL-RAD-I-010.

16.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS

Data recording, calculation, and reduction take place in accordance with GL-RAD-D-003 and GL-RAD-D-006.

17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL

Refer to GL-RAD-D-003 for instructions concerning the data review process, approval, and transmittal.

18.0 RECORDS MANAGEMENT

Records generated as a result of this procedure are maintained as quality documents in accordance with GL-QS-E-008 for Quality Records Management and Disposition.

19.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL

Radioactive samples and material shall be handled and disposed of as outlined in the Laboratory Waste Management Plan, GL-LB-G-001.

20.0 REFERENCES

20.1 EPA Environmental Monitoring and Support Laboratory. Las Vegas. Radiochemical Analytical Procedures for Analysis of Environmental Samples. March 1979.

20.2 EML Procedures Manual HASL-300, Volume I February 2000, Method U-02-RC, Revision 1.

20.3 DOE Methods Manual for Evaluating Environmental and Waste Management Samples, 1997 Edition, RP800, “Sequential Separation of Americium and Plutonium by Extraction Chromatography.”

20.4 Analytical Chemistry. Rapid Determination of Thorium-230 in Mill Tailings by α Spectrometry. UNC Geotech, Grand Junction Projects Office. Steve Donivan, Mark Hollenbach, and Mary Costello. Vol. 59, No. 21, 1987.

20.5 Los Alamos Health and Environmental Chemistry: Analytical Techniques. LA-10300-M Vol. 1, September 1987.

20.6 Special thanks to Dr. Bill Burnett and his associates for assistance in developing this method at Florida State University.

20.7 EML Procedures Manual HASL-300, Volume II February 1997, Method Am-05-RC.

20.8 U.S. Department of Energy, Environmental Measurements Laboratory Procedures Manual HASL-300, Section 4.5.4, Vol. 1, Pu-11-RC, 28th Ed., 1997

21.0 HISTORY

Revision 26: Added Appendix 7 to include steps of digestion of soil using EPA Method 3050B (Modified).
Revision 25: 1 mL of Titanium chloride to 0.5 mL in sample preparation section and checklist.

Revision 24: Updated Appendix 1. Combined steps 11.3.18 with step 11.3.17 for clarification.

Revision 23: Added DOE HASL-300 Pu-11-RC (modified) to Applicable methods on title page. Section 2.3 added Pu-11-RC as a source method. Updated reagent section. Added U-236 to section 9.2.1. Added section 11.1.4 regarding tracers. Note added after section 11.2.2.2 regarding Pu-241 analysis if run in tandem. Omitted section 11.2.3.2 and 11.2.3.3. Removed plutonium cookdown from sections 11.2.14 and 11.5. Removed MS requirement from section 12.2. Updated section 16.0.

Revision 22: Added step 11.2.2.4 and section 11.10.

Revision 21: Changed stainless steel to metal in sections 2.2 and 8.1.6.

Revision 20: Updated reagent section. Notes added after section 11.1.3.2 and 11.7.9 regarding Pu-241 analysis if run in tandem. Omitted cookdown procedure for Americium and Uranium. Updated sections 11.4 and 11.6 microprecipitation steps. Added Appendix 6: Sample Cleanup from an Alpha Spec Filter.

APPENDIX 1

AMERICIUM, CURIUM, PLUTONIUM, AND URANIUM

Use a 2.5 cm^3 column with 1X8 anion resin (Cl^- form 100-200 mesh)

COLUMN WORK

____ 10 mL 9 M HCl (Conditioning)

____ Load solution: 10 to 15 mL 9 M HCl / 0.04% H_2O_2 (Catch in C-Tube for Am/Cm)
NOTE: If U only is required the load solution is 10 to 15 mL of 9 M HCl

____ 5 mL 9 M HCl (Catch in C-Tube for Am/Cm then proceed to Appendix 2 or 3 as appropriate for Am/Cm procedure)

____ 15 mL 9 M HCl (Rinse)

____ **Elute** Pu: 10 mL 9 M HCl / 0.05 M NH_4I (Catch in C-Tube then proceed to Appendix 4 Plutonium Precipitation)

____ 15 mL 6 M HCl / 0.52 M HF (Rinse)

____ 5 mL 6 M HCl (Rinse)

____ **Elute** U: 15 mL 0.1 M HCl (Catch in C-Tube)

____ Proceed to Appendix 4 for Uranium Precipitation

APPENDIX 2

AMERICIUM / CURIUM CONTINUATION

AMERICIUM / CURIUM

____ 0.5 mL 1.25 M Calcium nitrate

____ 1.0 mL Phosphoric acid and swirl

____ Dilute to approximately 30 mL with DI water

____ Concentrated NH_4OH to pH of 8 to 10

____ Centrifuge samples and pour off supernate

____ Add approximately 25 mL DI water and shake samples to break up precipitate

____ Centrifuge samples and pour off supernate

____ 10 mL 2 M HNO_3 (Condition 2 mL TRU Resin Column)

____ Load Solution: 15 mL 2 M HNO_3 / 1 M $Al(NO_3)_3$

____ 5 mL 2 M HNO_3 (Rinse)

____ 5 mL 2 M HNO_3 (Rinse)

____ 5 mL 1 M HNO_3 (Rinse)

____ **Elute** Am/Cm: 20 mL 3 M HCl (Catch in C-Tube)

____ Proceed to Appendix 4 for Am/Cm precipitation

APPENDIX 3

AMERICIUM / CURIUM CONTINUATION

AMERICIUM / CURIUM

___ 5 mL 9 M HCl (Condition 2 mL TRU Resin Column)

___ Load solution from Appendix 1 (catch in drip pan)

___ 5 mL 9 M HCl (Rinse)

___ **Elute** Am/Cm: 20 mL 3 M HCl (Catch in C-tube)

___ Proceed to Appendix 4 for Am/Cm precipitation

APPENDIX 4

AMERICIUM / CURIUM PRECIPITATION

____ Dilute elution with DI water to approximately 40 mL

____ 0.1 mL 500 mg/L Neodymium and swirl

____ 5 mL 49% HF and swirl

____ Wait approximately 30 minutes

____ Filter

PLUTONIUM PRECIPITATION

____ Dilute elution with DI water to approximately 40 mL

____ 0.1 mL 500 mg/L Neodymium and swirl

____ Approximately 3 to 4 drops 25% Hydrazine dihydrochloride and swirl

____ Wait approximately 10 minutes

____ 5 mL 49% HF and swirl

____ Wait approximately 30 minutes

____ Filter

URANIUM PRECIPITATION

____ Dilute elution with DI water to approximately 40 mL

____ 0.1 mL 500 mg/L Neodymium and swirl

____ 0.5 mL Titanium chloride and swirl

____ Wait approximately 30 seconds

____ 5 mL 49% HF and swirl

____ Wait approximately 30 minutes

____ Filter

APPENDIX 5

RARE EARTH CLEAN-UP

____ Transfer elution from TRU column to a clean beaker and add 0.3 ml of lanthanum

____ Evaporate to dryness on low heat

____ 5 mL concentrated HNO_3 and approximately 2 mL of 30% H_2O_2. Evaporate to dryness on low heat.

____ 5 mL concentrated HNO_3 and approximately 2 ml of 30% H_2O_2. Evaporate to dryness on low heat.

____ Approximately 1 mL of 0.1 M Sulfuric Acid. Evaporate to dryness on low heat

____ Approximately 1 mL of concentrated Formic Acid. Evaporate to dryness on low heat

____ Approximately 1 mL of concentrated Formic Acid. Evaporate to dryness on low heat

____ 5 mL 4 M Ammonium thiocyanate/0.1 M Formic acid (Condition 2 mL TEVA column)

____ Load Solution: 10 mL 4 M Ammonium thiocyanate/0.1 M Formic acid

____ 5 mL 4 M Ammonium thiocyanate/0.1 M Formic acid (Rinse)

____ 10 mL 1.5 M Ammonium thiocyanate/0.1 M Formic acid (Rinse)

____ **ELUTE** Am: 20 mL of 2 M HCl (catch in C-tube)

____ Proceed to Appendix 4 for Am/Cm precipitation

APPENDIX 6

SAMPLE CLEANUP FROM AN ALPHA SPEC FILTER

1. Remove the filter from the mounting disc by wetting the filter with a small amount of acetone and pulling the filter off the disc using tweezers. Place the filter in a labeled small glass beaker.

2. Add 4-6 drops of iron carrier (10 mg/L), 10 mL of concentrated hydrochloric acid and 1.0 mL of 5% boric acid solution.

3. Fill the bulb end of a disposable pipette with DI water and turn upside down. Place on the filter in the glass beaker to ensure the filter remains submerged.

4. Heat on a hot plate for 30 minutes frequently stirring the filter, flipping it over then back etc. Use the disposable pipette to stir and flip.

5. Remove the filter from the solution and rinse with DI water. Do this over the glass beaker so the DI water rinse falls back into the beaker.

6. Evaporate to dryness.

7. Proceed to section 11.2.8 and perform separations as specified.

APPENDIX 7

SPECIAL PROCEDURE: DIGESTION OF SOILS AND SEDIMENTS BY EPA METHOD 3050B (MODIFIED)

- Complete Steps 11.1.1 thru 11.1.4 of this procedure
- Add 5 mL of [HNO_3] and 5 mL of Type I DI water to the samples and quality control samples
- Gently swirl the sample and acid mixture
- Cover the sample with a reflux cap or watch glass and heat the sample in a hot block at 95° +/- 5° C. Reflux the sample for 10 to 15 minutes
- Remove the samples from the hot block and allow the samples to cool
- Add 5 mL of [HNO_3], return samples to hot block, replace the watch glass, reflux for 30 minutes. If brown fumes are generated, indicating oxidation of the sample by nitric acid, add an additional 5 mL [HNO_3] until no brown fumes are given off by the sample.
- Using a ribbed watch glass or reflux cap, allow the solution to evaporate to approximately 5 mL, without boiling, or heat for 2 hours.
- Remove the sample from the hot block and allow to cool
- Add 2 mL of Type I DI water and 3 mL of 30% H_2O_2, return samples to hot block and allow the peroxide reaction to occur. Continue to add H_2O_2 in 1 mL increments until effervescence subsides. Do not add more than 10 mL of H_2O_2.
- Cover the samples with ribbed watch glass or reflux cap and heat the samples at 95° +/- 5° C for 2 hours, without boiling.
- Remove from hot block and allow the samples to cool
- Cap the samples and shake well
- Filter each sample with a 2.0 µm pore size plunger type filter (PTF grade) or allow to settle overnight.
- Transfer liquid phase to clean labeled centrifuge tube
- Proceed to Step 11.2.6 of this procedure

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF GAMMA ISOTOPES

(GL-RAD-A-013 REVISION 26)

APPLICABLE TO METHODS:
EPA 600/4-80-032 Method 901.1
DOE EML HASL-300 Section 4.5.2.3
DOE EML HASL-300 Ga-01-R

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GEL Laboratories LLC
2040 Savage Road Charleston, SC 29407
P.O. Box 30712 Charleston, SC 29417
Main: 843.556.8171 Fax: 843.766.1178

TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF GAMMA ISOTOPES 3
2.0 METHOD OBJECTIVE, PURPOSE, AND SUMMARY 3
3.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT 3
4.0 METHOD VARIATIONS 4
5.0 DEFINITIONS 4
6.0 INTERFERENCES 5
7.0 SAFETY PRECAUTIONS AND WARNINGS 5
8.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION 5
9.0 REAGENTS, CHEMICALS, AND STANDARDS 6
10.0 SAMPLE HANDLING AND PRESERVATION 6
11.0 SAMPLE PREPARATION 7
12.0 QUALITY CONTROL SAMPLES AND REQUIREMENTS 8
13.0 INSTRUMENT CALIBRATION, STANDARDIZATION, AND PERFORMANCE 8
14.0 ANALYSIS AND INSTRUMENT OPERATION 8
15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE 8
16.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS 8
17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL 8
18.0 RECORDS MANAGEMENT 8
19.0 LABORATORY WASTE HANDLING AND DISPOSAL 8
20.0 REFERENCES 8
21.0 HISTORY 10

1.0 STANDARD OPERATING PROCEDURE FOR THE DETERMINATION OF GAMMA ISOTOPES

2.0 METHOD OBJECTIVE, PURPOSE, AND SUMMARY

2.1 This standard operating procedure (SOP) provides the necessary instructions to conduct the analysis for gamma isotopes in water, soil, urine, filters, drinking water and miscellaneous matrices.

2.2 Water samples are typically counted in Marinelli beakers. Soil samples are typically sealed in aluminum cans, which can be counted immediately if Ra-226 is not desired. If Ra-226 is desired, the sealed can is set aside for minimum of 20 days to allow equilibrium between Rn-222 and Bi-214 to become re-established. Ra-226 is then quantified using the 609 keV line of Bi-214.

2.3 This method is based on the source method EPA 600/4-80-032 "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," August 1980, Method 901.1, and the Department of Energy (DOE) EML Procedures Manual source method for Gamma PHA in environmental samples, HASL-300 Section 4.5.2.3 and Ga-01-R, Gamma Radioassay.

2.4 This SOP is applicable for analyzing samples that contain radionuclides emitting gamma photons with energies ranging from about 5 to 2000 keV (including I-131).

3.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT

3.1 Minimum Detectable Activity (MDA): The MDA is based upon sample volume, Compton background, instrument efficiency, count time, and other statistical factors, as well as specific isotopic values such as abundance and half-life. A typical detection limit is 10 pCi/L or 0.1 pCi/g (based on Cs-137). The MDA for drinking water samples is 10 pCi/L (based on Cs-137).

3.2 Method Precision: Typical Relative Percent Difference (RPD) is 20% or less or 100% or less if the activity is less than five times the MDA.

3.3 Method Bias (Accuracy): The method accuracy requirement for gamma, measured by running a Laboratory Control Sample (LCS) with each batch, is 25% of the true value. For drinking water samples, laboratory fortified blanks (LFB, equivalent to LCS) recoveries should be between 90-110% of the known value.

3.4 Procedures contained in this SOP may be used to analyze REMP samples.

3.5 Analysts training records are maintained as quality records as outlined in GL-QS-E-008. Analysts training and proficiency in the method is outlined in the Employee Training SOP GL-HR-E-002.

3.6 For drinking water samples, analyst initial and ongoing demonstrations of proficiency will follow critical elements for radiochemisrtry, chapter VI, section

1.5, of The Manual for the Certification of Laboratories Analyzing Drinking Water (reference 20.5).

3.7 Sensitivity studies will follow critical elements for radiochemistry, chapter VI, section 7.3 of The Manual for the Certification of Laboratories Analyzing Drinking Water (reference 20.5).

4.0 METHOD VARIATIONS

4.1 Some variations may be necessary due to special matrices encountered in the lab. These variations may be used with approval from a Group Leader or Team Leader. Variations to a method will be documented with the analytical raw data.

4.2 Filter samples can either be counted directly, or digested prior to counting. If filters are digested, they are digested in accordance with GL-RAD-A-026.

4.3 No method modifications are permitted for drinking water samples.

5.0 DEFINITIONS

5.1 National Institute of Standards and Technology (NIST): For the purpose of this method, the national scientific body responsible for the standardization and acceptability of analyte solutions.

5.2 Deionized (DI) water: Type I water.Refer to GL-LB-E-016.

5.3 AlphaLIMS: GEL's Laboratory Information Management System.

5.4 Batch: Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents.

5.5 Method Blank (MB): A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples containing an analyte of interest through all steps of the analytical procedures.

5.6 Laboratory Duplicate (DUP): For soils, when sufficient sample is available, a separate duplicate will be prepared. For liquid samples and when sufficient sample is not available for solids, an independent count of the sample container will be performed to show precision.

5.7 Laboratory Control Sample (LCS): A sample matrix, similar to the batch of associated samples (when available) that is free from the analytes of interest, spiked with verified known amounts of analytes from a source independent of the calibration standards or a material containing known and verified amounts of analytes. The LCS is equivalent to a Fortified Blank in the EPA drinking water compliance manual (See to section 20.5).

5.8 Refer to SOP GL-QS-B-001 the Quality Assurance Plan for additional lab-wide used definitions.

6.0 INTERFERENCES

6.1 Some gamma isotopes emit gamma lines that may overlap with other isotopes. If the energies of the two isotopes are within the energy tolerance setting, the peaks may not be resolvable and may give a positive bias to the result. This problem is minimized by careful review of the peak search.

6.2 Soil samples may vary in density from the standard used for calibration. A density correction is applied to the "CAN" geometry. This correction was determined using solids with weights varying between 54 g and 192 g.

7.0 SAFETY PRECAUTIONS AND WARNINGS

7.1 Keep hands free from moving parts of canning device and gamma shields.

7.2 Personnel performing this analytical procedure are trained in and follow the safe laboratory practices outlined in the Safety, Health and Chemical Hygiene Plan, GL-LB-N-001.

7.3 Personnel handling radioactive materials are trained in and follow the procedures outlined in GL-RAD-S-004 for Radioactive Material Handling.

7.4 Personnel handling biological materials are trained in and follow the procedures outlined in GL-RAD-S-010 for The Handling of Biological Materials.

7.5 If there is any question regarding the safety of any laboratory practice, **stop immediately**, and consult qualified senior personnel such as a Group or Team Leader.

8.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION

8.1 Ancillary Equipment

8.1.1 100 cc aluminum cans with lids for soil and miscellaneous samples

8.1.2 10 cc Gelman Sciences Petri dish for soil, filters and miscellaneous samples

8.1.3 2 L and 500 mL Marinelli beakers for water samples

8.1.4 Air displacement pipettes

8.1.5 Can sealing tool

8.1.6 Graduated cylinder

8.1.7 25 cc VWR Petri for soil and miscellaneous samples

8.1.8 250 mL plastic jar for filters, soil, and miscellaneous samples

8.1.9 Hot plate

8.1.10 Teflon beakers and lids

8.1.11 1 L Marinelli beaker for soil samples

8.2 Instrumentation

8.2.1 High purity germanium detector, with associated electronics and data reduction software

8.2.2 Top loader balance

9.0 REAGENTS, CHEMICALS, AND STANDARDS

9.1 NIST traceable mixed gamma standard in 100 cc aluminum can

9.2 NIST traceable mixed gamma standard in 2.0 L Marinelli beaker

9.3 NIST traceable mixed gamma standard in 0.5 L Marinelli beaker

9.4 NIST traceable mixed gamma standard in Gelman Sciences 10 cc Petri dish

9.5 NIST traceable mixed gamma standard in 13, 47 mm glass fiber filter composites in Gelman Sciences Petri dish.

9.6 NIST traceable mixed gamma standard in 0.4 L jar

9.7 NIST traceable mixed gamma standard in 0.25 L jar

9.8 NIST traceable mixed gamma standard in 1, 47 mm glass fiber filter

9.9 NIST traceable mixed gamma standard in Impregnated Charcoal Sample Cartridge.

9.10 NIST traceable mixed gamma standard in VWR (53 mm x 15 mm) Petri dish (approximately 25 cc)

9.11 NIST traceable mixed gamma standard in aqueous solution

9.12 NIST traceable mixed gamma standard in 1.0 L Marinelli beaker

9.13 NIST traceable mixed gamma standard in 20 mL liquid scintillation vial

9.14 16 M Nitric acid, reagent grade (HNO_3)

10.0 SAMPLE HANDLING AND PRESERVATION

10.1 For soil samples, 500 g of sample should be collected, preferably in a plastic container to avoid breakage.

10.2 For water samples, 2 L of sample should be collected in a plastic container and preserved to a pH < 2 with nitric acid.

10.2.1 Before beginning an analysis, the analyst should check the sample pH by removing a minimal amount of sample with a transfer pipette and placing it on a pH strip. DO NOT insert pH strip into sample container. If the sample is received with a pH greater than 2, the analyst should contact the Group Leader or Team Leader.

NOTE: If the analysis is requesting I-131 (or any other iodine isotopes) Analysis without preserving is acceptable. If a sample is preserved with acid without stabilizing the iodine, Iodine may volatilize and escape the solution as a gas.

10.2.2 If approved by the client, the analyst should adjust the pH with nitric acid to a pH < 2. If the sample pH is adjusted, let the sample sit in the original container for a minimum of 24 hours before analysis. This

acidification should be documented on a batch history sheet and attached to the batch paperwork.

10.3 For filters no preservation is necessary.

11.0 SAMPLE PREPARATION

11.1 Solid Sample Preparation.

11.1.1 Prepare the sample for gamma counting in accordance with SOP GL-RAD-A-021, Soil Sample Preparation for the Determination of Radionuclides.

11.1.2 Fill the appropriate container with sample prepared from step 11.1.1 using the following steps as a guideline:

11.1.2.1 If Ra-226 analysis is required, the sample is placed in a 100 cc can for in-growth.

NOTE: It is recommended that in-growth be allowed 20 days to quantify Ra-226. Shorter ingrowth periods can be used at the request of the client. However, shorter in-growth periods may decrease the accuracy of the data. If there is insufficient mass of sample to fill the 100 cc can, contact the Team or Group Leader.

11.1.2.2 If sufficient mass is available, homogenized samples should be placed in the 100 cc can. Determine the net weight of the sample. If the net weight is less than 54 g or greater than 192 g, contact the Team or Group Leader to determine the appropriate counting container. Record sample weight and date in AlphaLIMS and on sample container.

11.2 Water Sample Preparation

11.2.1 Place the appropriate labeled Marinelli beaker (typically 500 mL or 2 L) on a balance and tare the balance.

11.2.2 If less than approximately 1.1 L is available, sample should be poured into a 500 mL Marinelli beaker.

11.2.3 Transfer the appropriate volume to the tared container and record the volume of the sample on the Queue sheet.

NOTE: If there is insufficient sample to fill the Marinelli, record the exact amount of sample volume on the container and on the Queue sheet. Dilute the sample to the appropriate volume to maintain the calibration geometry. Record the volume the sample was diluted to on the sample container, also.

11.2.4 The MB should be recorded on the Queue sheet to be the same aliquot as the largest sample in the batch. An empty Marinelli beaker should be labeled as the MB and submitted with each batch of samples.

11.2.5 Submit the Marinellis and completed paperwork to the count room for gamma counting analysis.

11.3 Urine Sample Preparation

11.3.1 Refer to GL-RAD-B-030.

11.4 Preparation of Miscellaneous Matrices

11.4.1 Prepare the sample in accordance with GL-RAD-A-026 for The Preparation of Special Matrices for the Determination of Radionuclides.

11.4.2 If sample(s) was (were) received from the client in a container that matches a calibrated geometry, a direct count of the sample can be performed.

12.0 QUALITY CONTROL SAMPLES AND REQUIREMENTS

Refer to GL-RAD-D-003.

13.0 INSTRUMENT CALIBRATION, STANDARDIZATION, AND PERFORMANCE

Refer to GL-RAD-I-001.

14.0 ANALYSIS AND INSTRUMENT OPERATION

Refer to GL-RAD-I-001.

15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

Refer to GL-RAD-I-010.

16.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS

Data recording, calculation and reduction take place in accordance with SOP GL-RAD-D-003 and GL-RAD-D-006.

17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL

Data are reviewed and packaged in accordance with GL-RAD-D-003 for Data Review, Validation, and Data Package Assembly.

18.0 RECORDS MANAGEMENT

Records generated as a result of this procedure are maintained as Quality Documents in accordance with GL-QS-E-008 for Quality Records Management and Disposition.

19.0 LABORATORY WASTE HANDLING AND DISPOSAL

Radioactive samples and material shall be handled and disposed of as outlined in the Laboratory Waste Management Plan, GL-LB-G-001.

20.0 REFERENCES

20.1 USEPA. Prescribed Procedures for Measurement of Radioactivity in Drinking Water, Method 901.1, August 1980.

20.2 Canberra Nuclear Genie System Spectroscopy, Applications and Display User's Guide, Vol. I and II, May 1991.

20.3 DOE EML Procedures Manual, HASL-300, 27th Edition. (Section 4.5.2.3)

20.4 DOE EML Procedures Manual, HASL-300, 28th Edition. (Ga-01-R)

20.5 Manual for the Certification of Laboratories Analyzing Drinking Water. Criteria and Procedures Quality Assurance. Fifth Edition EPA 815-R-05-004 January 2005.

21.0 HISTORY

Revision 22: Updated ingrowth period for Ra-226 to 20 days.

Revision 23:Procedure updated to include requirements for drinking water samples.

Revision 24: Changed recovery limit for laboratory fortified blank from 90-100% to 90-110% in section 3.3.

Revision 25: Type II to type I water.

Revision 26: Removed reference to obsolete software. Updated the reagents and standards section. Updated sample prep section to current practices.

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE

FOR

GAMMA SPECTROSCOPY SYSTEM OPERATION

(GL-RAD-I-001 REVISION 21)

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TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR GAMMA SPECTROSCOPY SYSTEM OPERATION 3
2.0 METHOD OBJECTIVE, PURPOSE, CODE AND SUMMARY 3
3.0 APPLICABLE MATRIX OR MATRICES 3
4.0 METHOD SCOPE, APPLICABILITY AND DETECTION LIMIT 3
5.0 METHOD VARIATIONS 3
6.0 DEFINITIONS 3
7.0 INTERFERENCES/LIMITATIONS 3
8.0 SAFETY PRECAUTIONS AND WARNINGS 4
9.0 APPARATUS, EQUIPMENT AND INSTRUMENTATION 4
10.0 REAGENTS AND STANDARDS 4
11.0 SAMPLE HANDLING AND PRESERVATION 4
12.0 SAMPLE PREPARATION 4
13.0 QUALITY CONTROL SAMPLES AND REQUIREMENTS 4
14.0 INSTRUMENT CALIBRATION, STANDARDIZATION AND PERFORMANCE 4
15.0 PROCEDURE FOR ANALYSIS AND INSTRUMENT OPERATION 9
16.0 EQUIPMENT AND INSTRUMENT MAINTENANCE 10
17.0 DATA RECORDING, CALCULATION AND REDUCTION METHODS 10
18.0 POLLUTION/CONTAMINATION 10
19.0 DATA REVIEW, APPROVAL AND TRANSMITTAL 10
20.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA 10
21.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS 10
22.0 RECORDS MANAGEMENT 10
23.0 LABORATORY WASTE HANDLING AND DISPOSAL 11
24.0 REFERENCES 11
25.0 HISTORY 11

1.0 STANDARD OPERATING PROCEDURE FOR GAMMA SPECTROSCOPY SYSTEM OPERATION

2.0 METHOD OBJECTIVE, PURPOSE, CODE AND SUMMARY

2.1 This standard operating procedure provides the necessary instructions to conduct the analysis for gamma isotopes using the Gamma Spectroscopy System.

2.2 Gamma emitting isotopes within the sample matrix are identified and quantified using gamma spectrometry. A sample aliquot is placed in a calibrated geometry and placed in the detector chamber. The germanium crystal therein produces a corresponding electrical pulse for the gamma photons that interact with the detector. The cumulative pulses are analyzed using software capable of quantifying gamma-emitting isotopes from the spectral data.

3.0 APPLICABLE MATRIX OR MATRICES

This is a nondestructive test for the measurement of gamma emitting isotopes in all matrices for which there is an available calibration standard.

4.0 METHOD SCOPE, APPLICABILITY AND DETECTION LIMIT

4.1 The aliquoted sample activity or sample position should be adjusted so that the detector system dead time remains less than 15%.

4.2 Method Detectable Activity: The MDA is based upon sample volume, instrument background, detector efficiency, count time and other statistical factors, as well as specific isotopic values such as abundance and half-life.

5.0 METHOD VARIATIONS

Not applicable

6.0 DEFINITIONS

6.1 Abundance: The combination of the isotopic decay branching ratio and the expected gamma emissions per disintegration of an isotope at a particular energy.

6.2 Key Line: The line chosen by the builder of the library to be the prominent line of the isotope. This line is used for the purposes of calculating activity, error and MDA.

6.3 AlphaLIMS: The Laboratory Information Management System used to store and report data.

6.4 National Institute of Standards and Technology (NIST): For the purpose of this method, the national scientific body responsible for the standardization and acceptability of analyte solutions.

6.5 Refer to GL-QS-B-001 the Quality Assurance Plan for additional Lab-wide used definition.

7.0 INTERFERENCES/LIMITATIONS

7.1 Some gamma isotopes emit gamma lines that may overlap with those from other isotopes. If the energies of the two isotopes are within the energy tolerance setting, the peaks may not be resolvable and may give a positive bias to the result. This problem is minimized by careful review of the peak search.

8.0 SAFETY PRECAUTIONS AND WARNINGS

Follow safety precautions as outlined in GL-LB-N-001 for the Safety, Health and Chemical Hygiene Plan.

9.0 APPARATUS, EQUIPMENT AND INSTRUMENTATION

9.1 Apparatus and Equipment

9.1.1 Compaq/DEC Alpha Station with OpenVMS

9.1.2 Canberra Genie-ESP Application Software

9.1.3 High purity germanium detector

9.1.4 Pulse processing electronics

10.0 REAGENTS AND STANDARDS

10.1 Standards

10.1.1 NIST traceable mixed gamma standards in geometries and densities, closely approximating analytical samples, used to calibrate the instrument.

11.0 SAMPLE HANDLING AND PRESERVATION

Refer to GL-RAD-A-013 The Determination of Gamma Isotopes.

12.0 SAMPLE PREPARATION

Refer to GL-RAD-A-013 The Determination of Gamma Isotopes.

13.0 QUALITY CONTROL SAMPLES AND REQUIREMENTS

Refer to GL-RAD-A-013 The Determination of Gamma Isotopes.

14.0 INSTRUMENT CALIBRATION, STANDARDIZATION AND PERFORMANCE

14.1 Calibration Standard

14.1.1 Mixed Gamma calibrations typically use a standard with 8-12 photons emitted over a range from approximately 45 keV to approximately 2000 keV.

14.1.2 Single nuclide calibrations typically use a standard comprised of the nuclide of interest.

14.2 Verification Standard

14.2.1 Mixed Gamma calibrations- A second source (from different manufacturer or if from the same manufacturer, a different lot number) is used for verification. The lines from Am-241, Cs-137 and Co-60 are used to verify the efficiency curve. These encompass the low, middle and high portions of the energy range.

14.2.2 Single nuclide calibrations – A second source (from a different manufacturer or if from the same manufacturer, a different lot number) is used for verification.

14.3 Standardization

14.3.1 High Voltage Adjust

14.3.1.1 See appropriate instrument manual for operation of electronics.

14.4 Calibration – Energy and efficiency calibrations are performed annually, upon initial instrument setup, after major repair or service, or when performance checks indicate a need.

NOTE: Expiration dates will match the last day of the month in which the calibration data was acquired.

14.4.1 Count Calibration Spectrum

14.4.1.1 Place the radioactive source on the detector.

14.4.1.2 Select **Calibration | Count a Calibration Standard** from the *Calibration* menu and click **OK**.

14.4.1.3 Enter the **Preset Live (secs):** in seconds and click **OK**. Count the standard until a minimum of 10,000 counts is acquired in each peak of interest.

14.4.2 Initial Energy & Shape Calibration

14.4.2.1 Select **Calibration Initial Energy & Shape Calibration** from the *Calibration* menu and click **OK**.

14.4.2.2 Select the detector.

14.4.2.3 Select the **Certificate File** from the drop down list. Click **OK**.

14.4.2.4 From the *Energy Calibration* dialog box highlight one of the energy lines listed.

14.4.2.5 Move the cursor in the MCA window to the corresponding channel expected for that energy line.

14.4.2.5.1 The apex of the peak of interest should be at the expected channel.

14.4.2.5.2 From the *Energy Calibration* dialog box click the **Cursor** button.

14.4.2.6 Repeat the previous step until all energy lines listed have been referenced with a corresponding channel.

14.4.2.7 From the *Energy Calibration* dialog box select the **OK** button.

14.4.2.8 The system will ask "Do you want to do a full energy and shape calibration?" Select **YES**.

14.4.2.9 The energy and shape calibrations will now be performed with all of the lines from step 14.4.2.6. Verify the energy and shape curve generated. Select **OK** to continue or **Cancel** to abort the calibration.

14.4.2.10 A new page will appear with the Energy Calibration Report and the FWHM Calibration Report. Review the columns marked difference. For the energy calibration, the absolute value of the difference must be less than 1.0 and for the FWHM calibration, the absolute value of the difference must be less than 0.5. Regardless of the results, select **Dismiss.**

14.4.2.11 A new pop-up screen will appear. If the results from the previous step were less than a 0.2 keV difference, select **OK**. If the results were greater than a 0.2 keV difference select **Cancel** and begin the energy calibration process again at step 14.4.1.

14.4.3 Energy Re-Calibrate

14.4.3.1 Select **Calibrate | Re-Calibrate | Energy and Shape Calibration** from the main menu and click **OK**.

14.4.3.2 Select the detector.

14.4.3.3 Select the certificate file and select the **OK** button.

14.4.3.4 The energy and shape calibrations will now be performed with all of the lines from step 14.4.2.6. Verify the energy and shape curve generated. Select **OK** to continue or **Cancel** to abort the calibration.

14.4.3.5 A new page will appear with the Energy Calibration Report and the FWHM Calibration Report. Review the columns marked difference. For the energy calibration, the absolute value of the difference must be less than 1.0 and for the FWHM calibration, the absolute value of the difference must be less than 0.5. Regardless of the results, select **Dismiss.**

14.4.3.6 A new pop-up screen will appear. If the results from the previous step were less than a 0.2 keV difference, select OK. If the were greater than a 0.2 keV difference select Cancel and begin the energy calibration process again. If it fails after re-calibration contact Group or Team Leader for further instructions.

14.4.4 Efficiency Calibrate

14.4.4.1 Select **Calibrate | Efficiency Calibrate** from the main menu.

14.4.4.2 Select the geometry that represents the standardized radioactive source and click **OK**. If the geometry doesn't exist select **Create New Geometry**, enter the name of the new geometry and select **OK**.

14.4.4.3 Select the certificate for the calibration standard and select the **OK** button.

14.4.4.4 The efficiency calibration curve will be displayed for review. Select Empirical fit, and Log scale.

14.4.4.5 To accept the calibration select **OK**, or select **Cancel** to abort.

14.4.4.6 Dismiss the Calibration report displayed to complete the calibration procedure.

14.4.4.7 In the DECterm type **EFFPlot,** then press ENTER the type **EFFPRINT** then hit ENTER. This will print the efficiency curve.

14.4.5 Efficiency Verifications

14.4.5.1 Verification counts are performed as a normal sample count starting at step 15.2.3 of this SOP.

14.4.5.2 No batch ID is assigned to verification counts, typically "VER" is used.

14.4.5.3 Select the only sample identification available regardless of how it is named.

14.4.5.3.1 You may be asked if you would like to extend the count. Select **NO**.

14.4.5.3.2 When the screen to enter the sample information appears (step 15.2.8), use the date and time indicated on the manufacturer's certificate file for decay correction and change the sample identification using the following naming convention: VER_DETECTOR_GEOMETRY, for example VER_GAM01_CAN.

14.4.5.4 Once the count has completed, in the DECterm, type "@print_virtual sample, where sample equals the same identification used in step 14.4.5.3.2. This will print out the raw data of the verification count.

14.4.5.5 Several pages will print out. The only pages needed are the background-subtracted peak report, which should be the first page, and the nuclide line activity report.

14.4.5.6 Place the results from the "Decay Corr" column into the appropriate Master Verification Spreadsheet located at S:\RAD\FORMS\EFF_VER (where S:= sdrive on 'gelsan') under the column named **Measured Activity**.

14.4.5.7 If necessary, enter the emission rate for the standard used for verification on the Master Verification Spreadsheet. This can be found on the manufacturer's certificate file for the standard. The spreadsheet will then calculate the **Calibrated Activity**. If a column for the emission rate does not exist on the spreadsheet, the **Calibrated Activity** can be calculated by using the values from the Decay Correct Source page in Alpha LIMS

(http://prodsvr01.gel.com:7778/pls/lims/de_ref_material.decay_correction).

14.4.5.8 The percent difference between the **Calibrated Activity** and **Measured Activity** is calculated by the spreadsheet and is displayed under the column marked **Difference**. The verification is considered acceptable if all values in the **Difference** column are less than 10%. If the **Difference** is 10% or greater, the verification is considered invalid and must be performed again. If two verifications fail notify Group Leader or Team Leader for further action.

14.5 Performance Checks

14.5.1 Daily Quality Control Calibration Check (QCC)

14.5.1.1 The QCC should be counted daily or prior to sample counting. If no samples are being counted this check is not required.

14.5.1.2 Load the QCC check source on the detector(s). If multiple QCC checks are being started skip to step 14.5.1.5.

14.5.1.3 From the PROcount window, select **QC | Calibration Check.**

14.5.1.4 Select the detector and select **OK**.

14.5.1.5 To start multiple QCC checks at once, select **QC | Multi Calibration Checks** from the PROcount window.

14.5.1.6 Highlight each detector you wish to start by clicking once on the detector name. Once you have highlighted all of the detectors you wish to start, select **OK**.

14.5.2 Daily Quality Control Background Check (QCB)

14.5.2.1 The QCB should be counted daily or prior to sample counting. If no samples are being counted this check is not required.

14.5.2.2 Ensure the detector shield(s) are empty prior to running the QCB. If multiple QCB checks are being started, skip to step 14.5.2.5.

14.5.2.3 From the PROcount window, select **QC | Background Check.**

14.5.2.4 Select the detector and select OK.

14.5.2.5 To start multiple QCB checks at once, select **QC | Multi Background Checks** from the PROcount window.

14.5.2.6 Highlight each detector you wish to start by clicking once on the detector name. Once you have highlighted all of the detectors you wish to start, select OK.

14.5.3 Weekly Environmental Background

14.5.3.1 Ensure the detector shield(s) is (are) empty. The same process will be used to start single and multiple weekly environmental background counts.

14.5.3.2 Select **Count | Start MultipleBackgrounds** from the PROcount window.

14.5.3.3 highlight each detector you wish to start by clicking once on the detector name. Once you have highlighted all of the detectors you wish to start, select **OK.**

14.5.4 Generating the Daily and Weekly Check Reports

14.5.4.1 Daily check reports will generate every day following the completion of the QCC and QCB counts for each detector that will be in operation.

14.5.4.2 In the DECterm, type the command "**@QA_REPORT D**" then hit ENTER.

14.5.4.3 Weekly check reports will be completed once per week, typically Monday, following the completion of the weekly background subtraction counts.

14.5.4.4 In the DECterm, type the command "**@QA_REPORT B**" then hit ENTER.

15.0 PROCEDURE FOR ANALYSIS AND INSTRUMENT OPERATION

15.1 Prepare the sample as outlined in GL-RAD-A-013 for The Determination of Gamma Isotopes.

15.2 Sample Counting

15.2.1 Prior to starting a sample count the detector used must be scanned into AlphaLIMS. In a web browser, enter the following address:

http://prodsvr01.gel.com:7778/pls/lims/inst_instrument.start_count

15.2.2 Each sample and detector are labeled with a Universal Product Code (UPC). First scan the UPC code for the detector and then scan the UPC code for the sample. Continue doing so for any additional sample counts. Once this has been done, select Submit on the web page.

15.2.3 Load the sample on the detector.

15.2.4 Select **Count | Start a Count** from the *ProCount Main Menu.*

15.2.5 Select a detector and select **OK**.

15.2.6 Enter the batch to be started and select OK.

15.2.7 Select the sample to be counted.

15.2.8 Enter the sample specific information into the Sample Information screen and select OK. (i.e., Count Time or LIMS Client Code)

NOTE: Sample Count Time cannot exceed the weekly BKG count time (1000 minutes)

15.2.9 Select the Analysis Sequence file used for analysis and select OK.

15.2.10 Select the counting geometry and select OK.

16.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

Refer to GL-RAD-I-010 for Counting Room Instrumentation Maintenance.

17.0 DATA RECORDING, CALCULATION AND REDUCTION METHODS

Data recording, calculation and reduction take place in accordance with GL-RAD-D-003 and GL-RAD-D-006.

18.0 POLLUTION/CONTAMINATION

Ensure all samples are bagged prior to counting to prevent instrument contamination.

19.0 DATA REVIEW, APPROVAL AND TRANSMITTAL

Refer to GL-RAD-D-003 for Data Review, Validation, and Data Package Assembly.

20.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA

Corrective action for out-of-control data might require instrument maintenance, re-analysis, using a new spike mix, or a more complex set of actions. When trouble-shooting measures (refer to Section 21) fail to bring an analytical process or data into control, a data exception report and/or corrective action should be initiated in accordance with GL-QS-E-004.

21.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS

Troubleshooting the instrument is a function of analyst experience. In-house service is obtained from GEL's Group Leader or other qualified personnel. If vendor assistance is needed, then the appropriate vendor is contacted. Maintenance logbooks are kept for each instrument and contain entries for both routine and non-routine maintenance procedures.

22.0 RECORDS MANAGEMENT

22.1 Each sample analysis that is performed is documented in the instrument run log in accordance with GL-LB-E-009 for Run Logs.

22.2 All raw data printouts, calculation spreadsheets, and batch checklists are filed with the sample data for archival in accordance with GL-RAD-D-003 for Data Review, Validation, and Data Package Assembly.

22.3 Instrument maintenance is recorded in accordance with GL-LB-E-008 for Basic Requirements for the Use and Maintenance of Laboratory Notebooks, Logbooks, Forms and Other Recordkeeping Devices.

22.4 Records generated as a result of this procedure are maintained as quality documents in accordance with GL-QS-E-008 for Quality Records Management and Disposition.

23.0 LABORATORY WASTE HANDLING AND DISPOSAL

Laboratory waste is disposed in accordance with the Laboratory Waste Management Plan, GL-LB-G-001.

24.0 REFERENCES

24.1 United States Department of Energy, Environmental Measurements Laboratory, HASL-300 The Procedures Manual of the Environmental Measurements Laboratory, 28th Edition, "Gamma Radioassay," Ga-01-R (Vol. 1), February 1997.

24.2 United States Environmental Protection Agency, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, Method 901.1, August 1980.

24.3 American National Standards Institute, American National Standard for Calibration and Use of Germanium Spectrometers for the Measurement of Gamma-Ray Emission Rates of Radionuclides, ANSI N42.14-1999, with the exception of section 8, which is more applicable to the software vendor.

24.4 Canberra Model 480720 ProCount-ESP Users Manual, September 2000.

24.5 Canberra Model 480726 Genie-ESP System Users Manual, September 2000.

24.6 Canberra Model 480198 Genie VMS Users Manual, 2000.

24.7 ASTM, International, Standard Practice for Setup, Calibration, and Quality Control of Instruments Used for Radioactive Measurements, D7282-6, Nov. 2010.

25.0 HISTORY

Revision 17: Updated sections 14.4.3.6 and 14.4.5.2 for clarification.

Revision 18: Added note to section 14.4 to clarify instrument calibration expiration dates.

Revision 19: Revised to include new GL-RAD-D-006 for calculations.

Revision 20: Updated Reference Section 24.3

Revision 21: Added NOTE for sample count not to exceed weekly Bkg count time (1000 minutes)

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE

FOR

LB4100 GROSS ALPHA/BETA COUNTER

OPERATING INSTRUCTIONS

(GL-RAD-I-006 REVISION 17)

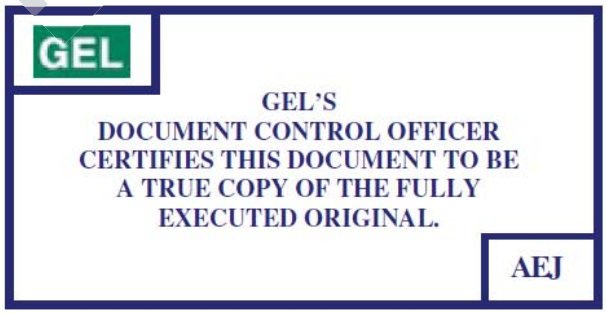

TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR LB4100 GROSS ALPHA/BETA COUNTER OPERATING INSTRUCTIONS 3
2.0 METHOD SUMMARY 3
3.0 APPLICABLE MATRIX OR MATRICES 3
4.0 METHOD SCOPE, APPLICABILITY AND DETECTION LIMIT 3
5.0 METHOD VARIATION 3
6.0 DEFINITIONS 3
7.0 INTERFERENCES/LIMITATION 3
8.0 SAFETY PRECAUTIONS AND WARNINGS 3
9.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION 4
10.0 SAMPLE HANDLING AND PRESERVATION 4
11.0 SAMPLE PREPARATION 4
12.0 QUALITY CONTROL SAMPLES 4
13.0 INSTRUMENT CALIBRATION, STANDARDIZATION AND PERFORMANCE 4
14.0 PROCEDURES 7
15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE 9
16.0 DATA RECORDING, CALCULATIONS AND REDUCTION METHODS 10
17.0 POLLUTION/CONTAMINATION CONTROL 10
18.0 DATA REVIEW, APPROVAL AND TRANSMITTAL 10
19.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA 10
20.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS 10
21.0 RECORDS MANAGEMENT 10
22.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL 10
23.0 REFERENCES 10
24.0 HISTORY 11

1.0 STANDARD OPERATING PROCEDURE FOR LB4100 GROSS ALPHA/BETA COUNTER OPERATING INSTRUCTIONS

2.0 METHOD SUMMARY

This procedure describes the operation of the Tennelec LB4100 Alpha/Beta Counting System for routine sample analysis. The operation includes access to the computer operating system, calibration, performance checks, starting of data collection, and the printing of data plots and reports.

3.0 APPLICABLE MATRIX OR MATRICES

Solids and Liquids

4.0 METHOD SCOPE, APPLICABILITY AND DETECTION LIMIT

This procedure is not specific to one particular method. For method scope, applicability or detection limit refer to the method specific analytical standard operating procedure.

5.0 METHOD VARIATION

Not Applicable

6.0 DEFINITIONS

6.1 Check Source: A radioactive source, not necessarily calibrated, that is used to confirm the satisfactory operation of the instrument.

6.2 Crosstalk: The detection of alpha events in the beta channel or the detection of beta events in the alpha channel during simultaneous counting.

6.3 Efficiency: The percent of decay events from a standard source that are seen and measured by a detector.

6.4 Proportional Counter: A gas filled radiation counter tube operated in the range of high voltage in which the total charge collected for each ionizing event is proportional to the number of ion pairs formed in the tube by the initial event.

6.5 Self Absorption: Absorption of radioactive emissions by the solids contained on the counting planchet, thereby preventing the emission from reaching the detector.

6.6 Simultaneous Counting: The measurement of both gross alpha and gross beta activity at the same time.

6.7 National Institute of Standards and Technology (NIST): For the purpose of this method, the national scientific body responsible for the standardization and acceptability of analyte solutions.

6.8 AlphaLIMS: GEL's Laboratory Information Management System.

7.0 INTERFERENCES/LIMITATION

For analyses requiring isotope specific analyses (i.e. Cl-36, Sr-90), chemical separations are performed during sample preparation to remove unwanted counting interferences.

8.0 SAFETY PRECAUTIONS AND WARNINGS

There are no specific safety requirements associated with the activity described in this procedure. Refer to the Safety, Health and Chemical Hygiene Plan, GL-LB-N-001, for basic safety and health information.

9.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION

9.1 Oxford Model LB4100 Gross Alpha/Beta Counting System.

9.2 Gas Regulator: Dual stage regulator recommended.

9.3 Radioactive Check Source: Contains an alpha and/or beta emitting isotope(s). The actual isotope is dependent on the radionuclide to be measured. Normally a Sr-90/Y-90 or Th-230 source is used.

9.4 Traceable Calibration Standard: NIST traceable standard based upon the isotope to be measured.

9.5 P-10 Gas (90% Argon/10% Methane)

10.0 SAMPLE HANDLING AND PRESERVATION

Not applicable

11.0 SAMPLE PREPARATION

See appropriate sample preparation procedure.

12.0 QUALITY CONTROL SAMPLES

Refer to GL-RAD-D-003 for Data Review, Validation and Data Package Assembly.

13.0 INSTRUMENT CALIBRATION, STANDARDIZATION AND PERFORMANCE

Calibration of the instrument shall be performed at initial installation. The calibration will be reestablished and/or reverified on an annual frequency, after changing detectors, following system maintenance that may affect the electronics, or when a problem is suspected. The instrument's window settings should not be changed after the initial set up. If the window settings are altered, all calibrations for the instrument must be renewed.

NOTE: For Drinking Water Compliance Monitoring-If a gas proportional counter is moved, serviced, or had an interruption in either gas flow or electrical power, the plateau voltage for both alpha and beta is verified, its crosstalk factors remeasured, and the solids absorption curves for each analyte reverified or regenerated prior to measuring any compliance monitoring samples.

NOTE: Expiration dates will match the last day of the month in which the calibration data was acquired.

NOTE: After initial Plateau generation, the regeneration of a Plateau to determine the Operating Voltage is not required, unless indicated by instrument response or performance as determined through daily performance checks, control charts, and calibration verifications (ANSI N42.25). If a generation of a Plateau is not required, proceed to step 13.3 of this calibration section.

13.1 Determining the Operating Voltage

The operating voltage of the LB4100 is determined by performing a plateau. The plateau is performed by counting a Sr-90 source long enough to achieve 10,000 counts. The source is repeatedly counted as the voltage of the instrument is increased.

13.2 Performing a Plateau

13.2.1 Load a Sr-90 source into each one of the instruments that is to be calibrated.

13.2.2 Click "Create" on the unit status window. Highlight the "Plateau" application and click on detectors to be started. Change the data file name to "PLTMMYY" where "MM" is the month and "YY" is the year (example: PLT0508 for May 2008 plateau). Set all sample IDs to "Sr-90" and all count times long enough to achieve 10,000 total beta counts. Click "Done" to begin plateau.

NOTE: Although the plateau application parameters have been preset, they should be verified prior to running the plateau: Starting Voltage = 0, Ending Voltage = 1800, Volts per step = 30, count time per step = 0.5 min, Time between steps = 0.01 min.

13.2.3 Once the plateau has been completed, the data may be printed and graphed. The optimum operation voltage for beta counting is approximately 30-150 volts above the knee of the curve. The knee is determined by drawing straight lines along the rising slope and the plateau portions of the curve; the knee is the point where these two lines intersect. The operating voltage is typically the first point on the plateau (flat portion of the curve.) The plateau length should be at least 200 volts. The percent slope per 100 volts should be 10% for distributed sources. This will yield good efficiency with the lowest background.

NOTE: Changing the operating voltage will invalidate all calibrations operating at the previous voltage. Contact the Group Leader before changing the operating voltage.

13.3 Source preparation for the crosstalk and efficiency determinations can be located in each isotopic SOP as each calibration is matrix/isotope specific.

13.4 Crosstalk Determination

Crosstalk determination is the measurement of alpha events in the beta channel or beta events in the alpha channel. Crosstalk is determined on an annual basis, usually coinciding with the gross alpha/beta calibration. These crosstalk values are used in all calibrations for the instrument.

13.4.1 Determining Alpha Crosstalk

Alpha crosstalk is the measurement of alpha events in the beta channel. The value is determined by counting a set of pure alpha emitting sources (Po-210), which should increase in mass similarly to calibration efficiency sources, long enough to achieve 10,000 total alpha counts each. The alpha crosstalk value is calculated by dividing the number of resulting beta counts by the number of resulting alpha counts. Source mass vs. %crosstalk should be plotted, and the coefficients of the curve should be used in calculating alpha crosstalk for all samples.

NOTE: For Drinking Water Crosstalk determination, Th-230 will be used to determine crosstalk values. The crosstalk values will be optimized using a Po-210 mass attenuation curve.

13.4.2 Determining Beta Crosstalk

Beta crosstalk is the measurement of beta events in the alpha channel. A set of Sr-90 sources should be counted in each detector, long enough to achieve 10,000 total beta counts. Beta crosstalk should be calculated for each source by dividing total alpha counts by total beta counts. An average of all of the sources crosstalk values should be calculated for each detector, and this average value will represent that detector's beta crosstalk.

13.5 Efficiency Determination

An efficiency for each detector is determined per method. For Ra-228 in all matrices except drinking water, an average efficiency is determined for each detector. This is accomplished by counting a set of at least 4 identical sources in each detector long enough to achieve 10,000 total beta counts. Efficiency is calculated as cpm/dpm and an average of the efficiencies for each detector is determined. For all other methods counted on the instrument, a set of sources that increase in mass is counted long enough to achieve 10,000 total counts for each source in the respective channel. Efficiency (cpm/dpm) is determined and plotted against the mass of the source. The coefficients of the plotted curve are used to determine efficiency per sample, corresponding to the sample's mass.

NOTE: For the above generated efficiency curves, each data point should be within 10% of the calculated value of the curve. If any data points exceed the acceptance criteria, the GL should be consulted for evaluation and possible exclusion of the outlier.

13.6 Efficiency Verification

The determined efficiency of each detector for each calibration must be verified with an independent NIST traceable source prior to using the newly established efficiencies. The result of each verification source when calculated with the new efficiency must be $\pm$ 25% of the known value.

13.7 Daily Checks

13.7.1 Ensure the daily QC and Background checks are completed (explained below) during the first part of the workday and entered into the control chart program. The results of this daily check are maintained on the AlphaLIMS system. The control charts provide a means to evaluate detector performance, conformance, and trends.

13.7.2 Background Check

13.7.2.1 Clean sample carriers with DI water and paper towels.

13.7.2.2 Load blank planchettes.

13.7.2.3 Click "Create" on the unit status window.

13.7.2.4 Highlight appropriate application count time (eg., 60 min for daily background, 500 min/1000 min for weekly background).

13.7.2.5 Click on detectors to be started, enter "BKG" as data file name and click "Run."

13.7.2.6 Click "Done" on sample entry window.

13.7.2.7 Check and confirm that P-10 gas pressure to instrument is between 0.1 to 0.3 standard cubic feet per hour (scfh). If not, contact the Group Leader or designee.

13.7.2.8 Ensure the LB4100 data control program is on. This program will automatically transfer data to AlphaLIMS.

13.7.3 Efficiency Check

Daily, prior to counting samples, daily efficiency QC checks are required. Separate alpha and beta QC check sources are counted for 5 minutes each.

13.7.3.1 Load efficiency planchettes into the instrument (either alpha or beta).

13.7.3.2 Click "Create" on unit status window.

13.7.3.3 Highlight "5min" application and click on detectors to be started.

13.7.3.4 Enter "EFFA" or "EFFB" into data file name field and click RUN.

13.7.3.5 Click "Done" on sample entry window.

13.7.3.6 Check and confirm that P-10 gas pressure to instrument is between 0.1 and 0.3 scfh. If not, contact the Group Leader or designee.

13.7.3.7 Ensure the LB4100 data control program is on. This program will automatically transfer data to AlphaLIMS.

13.7.4 Viewing Daily Reports

13.7.4.1 Once background and efficiency checks have finished counting, the data can be reviewed and evaluated using Microsoft Excel.

13.7.4.2 Open Excel. From the Rad Menus screen, click "GFPC dailies", enter the date of the report needed, click "OK".

13.7.4.3 Excel will generate a detector lockout exclusion report. This is a list of all detectors that have not passed acceptance criteria. Refer to GL-RAD-I-012 for details on lockout criteria.

14.0 PROCEDURES

14.1 Startup

The LB4100 software (OSUM) is usually left running, however, it can be opened by clicking on the "LB4100_W" icon on the desktop.

14.2 LB4100 Overview

The LB4100 is a multidetector low background counting system intended for the gross counting of alpha and beta emitters.

14.2.1 There are three units: Drawers A-D, Drawers E-H, and Drawers I-J. A drawer contains four detectors arranged in a square. These are covered by an overlapping guard detector for effective rejection of cosmic-ray events. After placing a sample in a drawer, the drawer must be closed and locked before counting to allow the sample carriers to be closer to the detector. A drawer must not be opened until samples have completed counting. If a lock switch is turned while detectors are counting, the software will pause the count until the switch is in the correct position.

14.2.2 The LB4100 system controller display indicates which detectors in each drawer are currently enabled. The grid lights up to show how much activity is being detected; a yellow light is used to show individual sample activity. The red light above the detectors indicates counts in the guard channel.

14.2.3 One computer controls the units; however, each unit contains detectors named by the software as A-D drawer. The red unit consists of A-D drawers. The violet unit consists of E-H drawers. The blue unit consists of I-J drawers.

14.2.4 On the OSUM software, the detector color indicates its status. Red indicates the detector lock switch is not in a counting position. Green indicates the detector is ready to count. Yellow indicates the detector is currently counting. A blinking yellow/green indicates the count is complete and is ready to reload.

14.2.5 Applications are used to define counting parameters (mainly counting time and operating voltage) for each unit. If there is no application for a specific count time, it is necessary to edit the “Generic” application (all applications named by count times are copies of the generic application as discussed in 14.2.6). To edit, right-click on the unit icon at the top of the OSUM window. Click “Edit applications” and double-click on the application to be edited. Input new count time (in minutes) into the appropriate field. No other parameter should be changed (e.g., operating voltage). When updates have been completed, click on the “Close” button to save changes or “Cancel” to abort editing window. Once a count using the “Generic” application has started, the “Generic” application can be edited again and restarted for a different count time. The list of parameters in the “Generic” application at the time of the count starting will be followed.

14.2.6 A new application can be created by modifying the configuration file and other Excel files within the OSUM software directory. Follow 14.2.6.1

to add a new application to the red unit. Besides differing color names, the instructions are the same for violet and blue.

14.2.6.1 Close OSUM software. In the directory C:\OSUM\LB4100\RED\, open the configuration file named "Red" in the notepad.

14.2.6.2 In this file, under "Applications List," add another application number and new name of application (e.g., Application XX=NEWAPP, where XX equals one integer larger than the last application number and NEWAPP is the < 8-character name of the new application).

14.2.6.3 Scroll down. Under "Application Definitions," copy the "[Generic]" area and paste a copy at the bottom of the list. Rename that copy "[NEWAPP]" and change "XLPFilename=Generic" to "XLPFilename=NEWAPP." Save configuration file and close.

14.2.6.4 In the directory C:\OSUM\LB4100\RED\, click on "Generic.XLP." Right click and click copy. Paste copy into the same directory. Rename copy "NEWAPP.xlp."

14.2.6.5 Restart OSUM software. Refer to 14.2.5 for instructions on how to edit the new application.

14.3 Counting Sample

14.3.1 Click "Create" on the unit status window. Highlight the appropriate application (count time). Click on detectors to be started. Type the batch number into the data file name field. Click "Run."

14.3.2 Enter sample IDs into the corresponding detector field. Clicking "Next" or hitting "Enter" on the keyboard will bring up the next detector. Click "Done" when all sample entry is complete.

14.3.3 Confirm that the gas pressure to instrument is 0.1 to 0.3 scfh. If not, contact the Group Leader or designee.

14.3.4 Once the sample counts have completed, the data will automatically save onto the network drive as long as the LB4100 data control program is open and running. If it is not open or not functioning, data transfer can occur manually. Once a count completes, sample data are stored in C:\OSUM\LB4100\"RED" or "Violet" or "Blue"\Data\ as a .TSV file. Copy this file into S:\GFPC\LB4100\Data for the red unit. Copy this file into S:\GFPC\LB4100\Data\EF for the violet unit. Copy this file into S:\GFPC\LB4100\Data\IJ for the blue unit.

15.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

Refer to GL-RAD-I-010 for Counting Room Instrument Maintenance.

16.0 DATA RECORDING, CALCULATIONS AND REDUCTION METHODS

Data recording, calculation, and reduction take place in accordance with GL-RAD-D-003 and GL-RAD-D-006.

17.0 POLLUTION/CONTAMINATION CONTROL

Not Applicable

18.0 DATA REVIEW, APPROVAL AND TRANSMITTAL

Refer to GL-RAD-D-003 Data Review, Validation and Data Package Assembly.

19.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA

Corrective action for out-of-control data might require instrument maintenance, re-analysis, using a new spike mix, or a more complex set of actions. When troubleshooting measures fail to bring an analytical process or data into control, a Data Exception Report (DER) and/or Corrective Action should be initiated in accordance with GL-QS-E-004 for Documentation of Nonconformance Reporting and Dispositioning and Control of Nonconforming Items, and/or GL-QS-E-002 for Conducting Corrective/Preventive Action and Identifying Opportunities for Improvement.

20.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS

Troubleshooting the instrument is a function of analyst experience. In-house service is obtained from GEL's Group Leader or other qualified personnel. If vendor assistance is needed, then the appropriate vendor is contacted. Maintenance logbooks are kept for each instrument and contain entries for both routine and non-routine maintenance procedures.

21.0 RECORDS MANAGEMENT

21.1 Each sample analysis that is performed is documented in the instrument run log in accordance with GL-LB-E-009 for Run Logs.

21.2 All raw data printouts, calculation spreadsheets and batch checklists are filed with the sample data for archival in accordance with GL-RAD-D-003 for Data Review, Validation and Data Package Assembly.

21.3 Instrument maintenance is recorded in accordance with GL-LB-E-008 for Basic Requirements for the Use and Maintenance of Laboratory Notebooks, Logbooks, Forms and Other Recordkeeping Devices.

22.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL

Refer to GL-LB-G-001 for GEL's Laboratory Waste Management Plan.

23.0 REFERENCES

23.1 Tennelec LB4100 Multi-Detector Low Background Alpha/Beta Counting System Instruction Manual," Canberra Industries, Inc.

23.2 ANSI N42.25-1997 Calibration and Usage of Alpha/Beta Proportional Counters.

NOTE: GEL incorporates this reference with the exception of section 6.5 for effectiveness of the Guard Detector which is not incorporated for use. The efficiency sources used in the calibration process typically achieve 10,000 gross

counts and the sources used in the cross talk and verification process typically achieve 5,000 gross counts.

23.3 DOE Quality Systems for Analytical Services.

24.0 HISTORY

Revision 11: Amended SOP to reflect new source check report generation.

Revision 12: Updated calibration information for clarification.

Revision 13: Calibration clarification.

Revision 14: Updated to comply with current process as part of annual review.

Revision 15: Updated for drinking water compliance monitoring to comply with DHEC certification extension requirements.

Revision 16: Updated to include drinking water crosstalk determination using Th-230 and Po-210

Revision 17: Added NOTE after Section 23.2.

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE

FOR

ALPHA SPECTROSCOPY SYSTEM

(GL-RAD-I-009 REVISION 15)

GEL

GEL'S
DOCUMENT CONTROL OFFICER
CERTIFIES THIS DOCUMENT TO BE
A TRUE COPY OF THE FULLY
EXECUTED ORIGINAL.

AEJ

GEL LABORATORIES, LLC
2040 Savage Road Charleston SC 29407
P.O. Box 39712 Charleston, SC 29417
Main: 843.556.7181 Fax: 843.766.1178

TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR ALPHA SPECTROSCOPY SYSTEM 3
2.0 METHOD OBJECTIVE, PURPOSE, CODE AND SUMMARY 3
3.0 APPLICABLE MATRICES 3
4.0 METHOD SCOPE, APPLICABILITY AND DETECTION LIMIT 3
5.0 METHOD VARIATIONS 3
6.0 DEFINITIONS 3
7.0 INTERFERENCES/LIMITATIONS 4
8.0 SAFETY, HEALTH AND ENVIRONMENTAL HAZARDS 4
9.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION 4
10.0 REAGENTS AND STANDARDS 5
11.0 SAMPLE HANDLING AND PRESERVATION. 5
12.0 SAMPLE PREPARATION. 5
13.0 QUALITY CONTROL SAMPLES. 5
14.0 STANDARDIZATION AND CALIBRATION 5
15.0 OPERATING PROCEDURE 12
16.0 EQUIPMENT AND INSTRUMENT MAINTENANCE 16
17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL 16
18.0 POLLUTION/CONTAMINATION 16
19.0 DATA RECORDING, CALCULATIONS, AND REDUCTION METHODS 16
20.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA 16
21.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS 16
22.0 RECORDS MANAGEMENT 16
23.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL 17
24.0 REFERENCES 17
25.0 HISTORY 17
APPENDIX 1: TROUBLESHOOTING 18

1.0 STANDARD OPERATING PROCEDURE FOR ALPHA SPECTROSCOPY SYSTEM

2.0 METHOD OBJECTIVE, PURPOSE, CODE AND SUMMARY

This method establishes the procedures for general use and calibration of the Canberra Alpha Spectroscopy System used to obtain and analyze alpha spectra for samples containing single or multiple alpha-emitting radionuclides. The operation of the Canberra Alpha Analyst and model 7401 alpha spectrometers is discussed. This method also describes how specific radionuclides are identified and quantified from the spectral data.

This procedure also outlines the required scheduled maintenance and performance checks for the instruments. In order to assure the optimum performance of count room instrumentation, it is necessary to perform regularly scheduled maintenance and instrument checks. The instrument checks include energy and efficiency calibration, which are conducted once a month, backgrounds, which are conducted weekly, and daily pulser checks. The scheduled maintenance provides a means of maintaining instrument performance, while minimizing the "down time" due to instrument failure and repair.

3.0 APPLICABLE MATRICES

Applies to all matrices.

4.0 METHOD SCOPE, APPLICABILITY AND DETECTION LIMIT

The procedure is not specific to one particular method. For method scope, applicability or detection limit refer to the method specific analytical standard operating procedure.

5.0 METHOD VARIATIONS

Not applicable.

6.0 DEFINITIONS

6.1 Average Efficiency: The average of the calculated efficiency of each isotope contained on the efficiency standard.

6.2 Background: Those counts that can be observed and thereby, allowed for by measuring a blank background planchet. These counts are attributable to environmental radioactivity, recoil contamination of the detector, electronic noise pulses, etc.

6.3 Efficiency: A percent of decay events from a standard radioactive source that are seen and measured by a detector.

6.4 Energy Calibration Offset: The energy (keV) that corresponds to the first channel on the Multichannel Analyzer for each chamber.

6.5 FWHM (Full Width Half Maximum): The full width of an alpha peak distribution measured at half the maximum peak height.

6.6 Peak Area: The number of counts contained within an alpha peak.

6.7 Peak Energy: The energy (keV) measured at the center of the alpha peak.

6.8 Peak Resolution: The FWHM value of the alpha peak.

6.9 Performance Check: Any operation performed on an instrument to verify its ability to conform to required specifications

6.10 PIPS detector: Passivated Implanted Planar Silicon

6.11 Scheduled Maintenance: Any operation performed on an instrument to prevent premature equipment failure

6.12 Traceable Calibration Standard: A calibrated radioactive source, with stated accuracy, whose calibration is certified by or to NIST (National Institute of Standards and Technology) or an equivalent organization.

6.13 National Institute of Standards and Technology (NIST): For the purpose of this method, the national scientific body responsible for the standardization and acceptability of analyte solutions.

6.14 AlphaLIMS: The Laboratory Information Management System used at GEL Laboratories, LLC.

7.0 INTERFERENCES/LIMITATIONS

For analyses requiring isotope specific analyses (i.e. U-238, Pu-238) chemical separations are performed during sample preparation to remove unwanted counting interferences.

8.0 SAFETY, HEALTH AND ENVIRONMENTAL HAZARDS

8.1 Refer to the Radioactive Material Handling Procedure (GL-RAD-S-004) for instructions on the handling of radioactive samples.

8.2 Refer to the Laboratory Waste Management Plan (GL-LB-G-001) for instructions on proper disposal of materials.

8.3 The detector bias supply must remain off, until the detector chamber reaches the normal operating vacuum, to prevent damage to the surface barrier detectors.

8.4 Turning off, or loss of power to, the vacuum pumps could lead to oil contamination of the alpha detectors. Therefore, all detectors must be brought to atmospheric pressure prior to turning the vacuum system off or immediately after a loss of power.

8.5 Follow the manufacturer's instructions for set up, intercomponent connections, and preliminary testing of the equipment. Observe all of the manufacturer's limitations and precautions.

8.6 Never exceed the manufacturer's recommended operating voltage for the detector; this may lead to detector damage.

9.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION

9.1 Canberra model 7401 Alpha Spectrometer

9.2 Canberra model 7200 Dual Alpha Analyst Spectrometer

9.3 Canberra model 7200 Controller

9.4 DEC/Compaq Alpha workstation or equivalent

9.5 Vacuum Pump

9.6 AMX analog multiplex or module

9.7 Acquisition Interface Module

9.8 ADC (analog to digital converter)

9.9 Vacuum pump and filtration rig

9.10 Disposable filter funnels (containing 25 µm filters with 0.1 mm pore size)

9.11 Stainless steel disks (29 mm diameter)

9.12 Stainless steel tweezers

10.0 REAGENTS AND STANDARDS

10.1 Traceable Calibration Standard - The actual standard is dependent upon the sample geometry being calibrated.

10.2 Vacuum Pump Oil

10.3 Silicone grease

11.0 SAMPLE HANDLING AND PRESERVATION

Not applicable.

12.0 SAMPLE PREPARATION

Not applicable.

13.0 QUALITY CONTROL SAMPLES

Not applicable.

14.0 STANDARDIZATION AND CALIBRATION

NOTE: Refer to GL-RAD-M-001 for guidance on the preparation of calibration sources for alpha spectroscopy.

14.1 Energy and Efficiency Calibration (Monthly checks for Alpha analyst detectors)

14.1.1 Alpha calibration standards are counted once each calendar month to update the detector energy and efficiency calibrations.

14.1.2 From the AMS Procedure window, select Displays then Chamber Status; ensure detectors are free for use.

14.1.3 Using a pair of tweezers, carefully position the appropriate calibration standard into each counter, taking care to center the calibration standard beneath the detector face and ensure the sample shelf is in the proper location.

14.1.4 Inspect the vacuum seal on the chamber door to ensure that no debris exists that may interfere with vacuum pressure. Clean the seal with a dry lint free cloth if necessary.

14.1.5 Close the chamber doors.

14.1.6 From the AMS Procedure window, select **Count** then **Primes**.

14.1.7 Enter a list of the chambers that you are starting and click **OK** or press **Enter**.

14.1.8 The detectors will automatically evacuate air from the chamber and apply a detector bias. The system then starts data acquisition on all alpha counters and counts the standards for a pre-determined time suitable to achieve greater than 10,000 counts in each applicable region of interest (Gd-148, Np-237, and Cm-244) typically 2 to 4 hours.

14.1.9 When the count is complete, the detector bias will automatically be turned off and the chamber vented to atmosphere.

14.1.10 When the calibration count is completed, proceed with section 14.3.

14.2 Energy and Efficiency Calibration (Monthly checks for model 7401 detectors)

14.2.1 Alpha calibration standards are counted once each calendar month to update the detector energy and efficiency calibrations.

14.2.2 From the DECterm VMS prompt, type **Count** to access the Sample Counting System Main Menu. If the Sample Counting System Main Menu is displayed, proceed with 14.2.3. If the Sample Counting System Main Menu is not displayed, consult with the Group Leader or their designee.

14.2.3 Select **1) Sample Counting** to access the Sample Counting Menu.

14.2.4 From Sample Counting Menu, Select **2) List Status of Detectors**; ensure detectors are free for use. Press **Return** to exit.

14.2.5 Using a pair of tweezers, carefully position the appropriate calibration standard into each counter, taking care to center the calibration standard beneath the detector face and ensure the sample shelf is in the proper location.

14.2.6 Inspect the vacuum seal on the chamber door to ensure that no debris exists that may interfere with vacuum pressure. Clean the seal with a dry lint free cloth if necessary.

14.2.7 Close the chamber doors and start evacuation of the chambers in accordance with section 15.5.

14.2.8 After normal operation vacuum is achieved, turn on detector bias.

14.2.9 Select **1) Count a New Sample** to access the Alpha Counting Menu.

14.2.10 Select **3) Monthly Calibration Check**.

14.2.11 Verify that all detector bias supplies are on, all pulsers are off. Enter a list of detectors to start, and press **Return**. The system then starts data acquisition on all alpha counters and counts the standards for a pre-determined time suitable to achieve greater than 10,000 counts in each applicable region of interest (Gd-148, Np-237, and Cm-244) typically 2 to 4 hours.

14.2.12 When the calibration count is completed, proceed with section 14.3.

14.3 Manually Processing the Monthly Calibrations

14.3.1 Proceed to DECterm VMS prompt. If the sample Counting System menu is still displayed on the DECterm, then exit to the DECterm VMS prompt by pressing **R** and **Return**.

14.3.2 Check the contents of the file **NAMES.DAT** by typing **EDIT NAMES.DAT**. Edit the contents of the file so it contains the entries **W###-W###**, depending on the detectors to be processed. When the contents of the file are correct, press **Control Z** followed by **Quit** if the changes are not to be saved, or Exit if the changes are to be save. Type **RANGE # #** to indicate which banks to show on the supervisor's action report.

14.3.3 At the prompt, type **Process** to start the processing of the calibrations.

14.3.4 At the **Initial or Update calibration? (I/U)** prompt, enter **U** to update the calibration or enter **I** to perform an initial calibration. Note that an initial calibration is done only under specific circumstances, such as initial setup of a counter. Consult the Group Leader or designee prior to performing an initial calibration. If a calibration update was chosen, the operator will be asked to verify the update energy and efficiency parameters for each detector.

14.3.5 Initial Calibration Only

14.3.5.1 At the prompt, use the mouse to position the cursor over the center of the specified nuclide on the spectrum display. Press **Return**.

14.3.5.2 Repeat for each nuclide.

14.3.6 Proceed with section 14.4.

14.4 Reviewing Monthly Calibration Report

14.4.1 After the monthly calibration data is processed, a supervisor's action report will be printed. Review the report for any out of control condition. Contact Group Leader or designee for out of control conditions. Detector should be removed from service if any of the following conditions exist: ABOVE/BELOW PSAREA,

NLACTIVITY, ECOFFSET, ECSLOPE, AVRGEFF, FWHMCONST, PSENERGY, PSFWHM.

NOTE: Refer to GL-RAD-I-012, Managing Statistical Data in the Radiochemistry Laboratory, for guidance on locking out detectors.

14.4.2 Update detector status board.

14.5 Daily Pulser Checks for Alpha analyst detectors

14.5.1 Daily pulser checks performed daily, prior to counting samples, to verify the proper operation of the detectors. Peak centroid, Pulser count rate, and peak FWHM are monitored and stored in quality assurance files.

14.5.2 From the AMS Procedure window, select **Displays** then **Chamber Status**; ensure detectors are free for use.

14.5.3 From the AMS Procedure window, select **Count** then **Pulsers**.

14.5.4 Enter a list of the chambers that you are starting and click **OK** or press **Enter**.

14.5.5 The detectors will automatically evacuate air from the chamber and apply a detector bias. The system then starts data acquisition on all alpha counters and counts the pulsers for 5 minutes.

14.5.6 When the count is complete, the detector bias will automatically be turned off and the chamber vented to atmosphere.

14.5.7 When the daily pulser count is completed, the data may be automatically processed and a Supervisor's Action Report is generated. If a report is generated, proceed with section 14.8. If a report is not generated, proceed with section 14.7.

14.6 Daily Pulser Checks for model 7401 detectors

14.6.1 Daily pulser checks performed daily, prior to counting samples, to verify the proper operation of the detectors. Peak centroid, Pulser count rate, and peak FWHM are monitored and stored in quality assurance files.

14.6.2 From the DECterm VMS prompt, type **Count** to access the Sample Counting System Main Menu. If the Sample Counting System Main Menu is displayed, proceed with 14.6.3. If the Sample Counting System Main Menu is not displayed, consult the Group Leader or their designee.

14.6.3 Select **1) Sample Counting** to access the Sample Counting Menu.

14.6.4 From Sample Counting Menu, **Select 2) List Status of Detectors**; ensure detectors are free for use. Press **Return** to exit.

14.6.5 If needed start evacuation of the chambers in accordance with section 15.5.

14.6.6 After normal operating vacuum is achieved, turn on detector bias and activate the detector pulser.

14.6.7 Select **1) Count a New Sample** to access the Alpha Counting Menu.

14.6.8 Select **2) Daily Pulser Check**.

14.6.9 Verify that all pulser and bias supplies are enabled for each detector. Enter a list of detectors to start. The system then starts data acquisition on all alpha counters and counts the pulsers for 5 minutes.

14.6.10 When the daily pulser count is completed, the data may be automatically processed and a Supervisor's Action Report generated. If a report is generated, proceed with section 14.8. If a report is not generated, proceed with section 14.7.

14.7 Manually Processing the Daily Pulser Checks

14.7.1 Proceed to the DECterm VMS prompt. If the Sample Counting System menu is still displayed on the DECterm, then exit to the DECterm VMS prompt by pressing **R** and **Return**.

14.7.2 Check the contents of the file **NAMES.DAT** by typing **EDIT NAMES.DAT**. Edit the contents of the file so it contains the entries **D###-D###**, depending on the number of detectors to be processed. When the contents of the file are correct, press **Control Z** followed by **Quit** if the changes are not to be saved, or **Exit** if the changes are to be saved. Type **RANGE # #** to indicate which banks to show on the supervisor's action report.

14.7.3 At the $ prompt, type **Process** to start the processing of the Daily Pulser Checks. The program proceeds to automatically process the pulser data one counter at a time.

14.7.4 Proceed with section 14.8.

14.8 Reviewing Daily Pulser Report

14.8.1 After the data is processed, a Supervisor's Action Report and Missing QA Report will be printed. Review the Supervisor's Action Report for any out of control conditions. Contact Group Leader or designee immediately for out of control conditions. Detector should be removed from service for the day if any of the following conditions exist: ABOVE/BELOW PSFWHM, PSENERGY, PSCENTRD, PSCTSS. Review the Missing QA Report for any detectors that may not have run Daily Pulser Checks. Perform section 14.6 or 14.5 as needed on any detectors listed on the Missing QA Report.

NOTE: Refer to GL-RAD-I-012, Managing Statistical Data in the Radiochemistry Laboratory, for guidance on locking out detectors.

14.8.2 Update detector status board.

14.9 Weekly Background Checks for Alpha Analyst detectors

14.9.1 Blank planchets are counted once each week to update the detector background counts.

14.9.2 From the AMS Procedure window, select **Displays** then **Chamber Status**; ensure detectors are free for use.

14.9.3 Using a pair of tweezers, carefully position the appropriate background planchets into each counter, taking care to center the planchet beneath the detector face and ensure the sample shelf is in the proper location.

14.9.4 Inspect the vacuum seal on the chamber door to ensure that no debris exists that may interfere with vacuum pressure. Clean the seal with a dry lint free cloth if necessary.

14.9.5 Close the chamber doors.

14.9.6 From the AMS Procedure window, select **Count** then **Backgrounds**.

14.9.7 Enter a list of the chambers that you are starting and click **OK** or press **Enter**.

14.9.8 The detectors will automatically evacuate air from the chamber and apply a detector bias. The system then starts data acquisition on all alpha counters and counts the backgrounds for the predetermined count time.

14.9.9 When the count is complete, the detector bias will automatically be turned off and the chamber vented to atmosphere.

14.9.10 When the background is completed, the data may be automatically processed and a Supervisor's Action Report generated. If a report is generated, proceed with section 14.12. If a report is not generated, proceed with section 14.11.

14.10 Weekly Background Checks for model 7401 detectors

14.10.1 Blank planchets are counted once each week to update the detector background counts. Weekly backgrounds are counted for 1000 minutes.

14.10.2 From the DECterm VMS prompt, type **Count** to access the Sample Counting System Main Menu. If the Sample Counting System Main Menu is displayed, proceed with 14.10.3. If the Sample Counting System Main Menu is not displayed, consult the Group Leader or their designee.

14.10.3 Select **1) Sample Counting** to access the Sample Counting Menu.

14.10.4 From Sample Counting Menu, Select **2) List Status of Detectors**; ensure detectors are free for use. Press Return to exit.

14.10.5 Using a pair of tweezers, carefully position the appropriate background planchets into each counter, taking care to center the planchet beneath the detector face and ensure the sample shelf is in the proper location.

14.10.6 Inspect the vacuum seal on the chamber door to ensure that no debris exists that may interfere with vacuum pressure. Clean the seal with a dry lint free cloth if necessary.

14.10.7 Close the chamber doors and start evacuation of the chambers in accordance with section 15.5.

14.10.8 After normal operating vacuum is achieved, turn on detector bias.

14.10.9 Select **1) Count a New Sample** to access the Alpha Counting Menu.

14.10.10 Select **3) Backgrounds**.

14.10.11 Verify that all detector bias supplies are on, all pulsers are off. Enter a list of detectors to start, and press **Return**. The system then starts data acquisition on all alpha counters and counts the backgrounds for the predetermined count time.

14.10.12 When the background count is completed, the data may be automatically processed and a Supervisor's Action Report generated. If a report is generated, proceed with section 14.12. If a report is not generated, proceed with section 14.11.

14.11 Manually Processing Weekly Backgrounds

14.11.1 Proceed to the DECterm VMS prompt. If the Sample Counting System menu is still displayed on the DECterm, then exit to the DECterm VMS prompt by pressing **R** and **Return**.

14.11.2 Check the contents of the file **NAMES.DAT** by typing **EDIT NAMES.DAT**. Edit the contents of the file so it contains the entries **B###-B###**, depending on the number of detectors to be processed. When the contents of the file are correct, press **Control Z** followed by Quit if the changes are not to be saved, or Exit if the changes are to be saved. Type **RANGE # #** to indicate which banks to show on the supervisor's action report.

14.11.3 At the $ prompt, type **Process** to start the processing of the background counts. The program proceeds to automatically process the background data one detector at a time.

14.12 Reviewing Weekly Background Report

14.12.1 After the data is processed, a Supervisor's Action Report will be printed. Review the printout for any out of control conditions. Contact

Group Leader or designee immediately for out of control conditions. Detector should be logged out for isotopes that have a high background.

NOTE: Refer to GL-RAD-I-012, Managing Statistical Data in the Radiochemistry Laboratory, for guidance on locking out detectors.

14.12.2 Update detector status board.

15.0 OPERATING PROCEDURE

15.1 Sample Counting (Alpha Analyst detectors)

15.1.1 From the AMS Procedure window, select **Displays** then **Chamber Status**; ensure detectors are free for use.

15.1.2 Open the door of the sample chamber. Carefully remove any sample that is in the chamber with a pair of tweezers and place it in a storage container.

15.1.3 Using a pair of tweezers, carefully position the next sample that is to be counted on the sample shelf, taking care to center the sample beneath the detector face and ensure the sample shelf is in the proper location.

15.1.4 Inspect the vacuum seal on the chamber door to ensure that no debris exists that may interfere with vacuum pressure. Clean the seal with a dry lint free cloth if necessary.

15.1.5 Close the chamber doors.

15.1.6 From the AMS Procedure window, select **Count** then **Samples**.

15.1.7 Enter a list of the chambers that you are starting and click **OK** or press **Enter**.

15.1.8 A window will appear indicating all detectors have started. Click **OK**.

15.1.9 The detectors will automatically evacuate air from the chamber and apply a detector bias. The system starts data acquisition on all alpha counters. The default count time is set to four (4) hours, but can be changed during step 15.3.4 if necessary.

15.1.10 If data acquisition is to be started on model 7401 detectors at the same time, proceed to section 15.2.

15.1.11 If only Alpha Analyst detectors are to be started, return to the DECterm window before proceeding further.

15.1.12 From the DECterm VMS prompt, type **Count** to access the Sample Counting System Main Menu. If the Sample Counting System Main Menu is displayed, proceed with 15.1.13. If the Sample Counting System Main Menu is not displayed, consult the Group Leader or their designee.

15.1.13 Select **1) Sample Counting** to access the Sample Counting Menu.

15.1.14 Select **1) Count a New Sample** to access the Alpha Counting Menu.

15.1.15 Select **1) Samples**.

15.1.16 At the "Use which detector bank to count (RETURN to end)": prompt, press **Return**.

15.1.17 Enter sample information for each sample in accordance with section 15.3.

15.2 Sample Counting (model 7401 detectors)

15.2.1 From the DECterm VMS prompt, type **Count** to access the Sample Counting System Main Menu. If the Sample Counting Main Menu is displayed, proceed with 15.2.2. If the Sample Counting System Main Menu is not displayed, consult the Group Leader or their designee.

15.2.2 Select **1) Sample Counting** to access the Sample Counting Menu.

15.2.3 From Sample Counting Menu, Select **2) List Status of Detectors**; ensure detectors are free for use. Press **Return** to exit.

15.2.4 Ensure that there are no jobs active which use the alpha spectrometer(s) that is to be loaded. Ensure the bias supply to the detector is off, and then vent the chambers in accordance with section 15.5.

15.2.5 Open the door of the sample chamber. Carefully remove any sample that is in the chamber with a pair of tweezers and place it in a proper storage container.

15.2.6 Using a pair of tweezers, carefully position the next sample that is to be counted on the sample shelf, taking care to center the sample beneath the detector face and ensure the sample shelf is in the proper location.

15.2.7 Inspect the vacuum seal on the chamber door to ensure that no debris exists that may interfere with vacuum pressure. Clean the seal with a dry lint free cloth if necessary.

15.2.8 Close the chamber doors and start evacuation of the chambers in accordance with section 15.5.

15.2.9 After normal operating vacuum is achieved, turn on detector bias.

15.2.10 Before starting acquisition, verify the proper operating bias.

15.2.11 Select **1) Start a New Count** to access the Alpha Counting Menu.

15.2.12 Select **1) Samples**.

15.2.13 Enter the bank of detectors to acquisition on (or press **Return** when all needed banks are on) and the sample count time. Repeat for each bank as needed.

15.2.14 Enter sample information for each sample in accordance with section 15.3.

15.3 Entering Sample Information

15.3.1 Enter the Batch ID (or press **Return** when all count data has been entered and proceed to 15.3.6). The system will gather batch information from AlphaLIMS if this is the first time the batch number has been entered. If the system appears to hang while "Getting batch information from AlphaLIMS" is displayed, type **Control-Y** to skip to the next step. (In this case, no default information will be provided.)

15.3.2 Enter/verify appropriate batch parameters. Press **PF1** to accept the batch parameters and exit the Parameter Editor.

15.3.3 Enter the detector number containing the sample. If all samples for the batch have been entered, type **P** (if the batch is ready to proceed to data review) or C (if batch is remaining in the count room) and press **RETURN**. If there are more batches to count, continue with section 15.3.1. If no other batches are to be started press **RETURN** and go to section 15.3.6.

15.3.4 The system then enters the Parameter Editor. Enter/verify the displayed information for the sample.

15.3.5 Press **PF1** to exit the Parameter Editor. Continue with 15.3.3 for the next sample.

15.3.6 Monitor detectors for high count rates. If the count rate exceeds 100 counts per minute (across the entire spectrum), turn off the bias, vent the chamber, remove the sample from the chamber, and contact the Group Leader (or designee) immediately. A one-hour background count may be necessary to confirm that the detector was not contaminated.

15.3.7 When sample counts are finished, each sample may be processed automatically. If spectrum data needs to be manually processed, proceed with section 15.4.

15.4 Processing Sample Data via AlphaGEL

15.4.1 This section assumes the operator has a general understanding of the Microsoft Windows operating environment.

15.4.1.1 AlphaGEL is a custom software package developed exclusively for GEL Laboratories, which runs from a PC.

15.4.1.1.1 Start the client program from the Windows start menu or the desktop icon.

15.4.1.1.2 If necessary, click "Network", then "Connect" to connect to the AlphaGEL server. Optionally, double-click on the red network

status indicator. Enter Username and Password if necessary.

15.4.2 Enter the batch number of the samples to process in the main box of the "Processing" frame of the "AlphaGEL Remote Connection-Client" window and click "View Batch Info" or press **Enter**.

15.4.3 Verify all sample information in the "Batch Information" window.

15.4.3.1 Sample information can be corrected by either double-clicking a cell or selecting a cell and pressing Enter.

15.4.3.2 Double-clicking the column header can change an entire column. This will cause all values in the column to be the same.

15.4.3.3 Sample information changes are not saved until "Confirm All Changes" is clicked.

15.4.3.4 If changes are to be discarded, clicking "Tools", "Revert to Saved" will restore the information to the last saved state.

15.4.3.5 Verify that the radioactive standards are correct by clicking "Standard" and reviewing the "Standards Information" window.

15.4.4 Mark the samples from the batch to process by using the left-hand column. "X" indicates that the sample will be processed. All samples are marked for processing when the batch is first opened.

15.4.5 Verify that the "Client Processing Options" are correct. If any changes to these needs to be made, consult with the Group Leader or their designee.

15.4.6 Click "Process this Batch" to begin processing the marked samples.

15.5 Vacuum pump operation for model 7401 detectors

15.5.1 Evacuation of Air from Alpha Spectrometer model 7401

15.5.1.1 Ensure that the vacuum manifold control is set to the **"pump down manifold"** position.

15.5.1.2 Place the **"pump/vent"** valve/switch on the spectrometer in the **"pump and locked"** position.

15.5.1.3 Repeat 15.5.1.2 for each chamber in the bank.

15.5.1.4 Monitor the pump down manifold vacuum gauge until the indicator is below 10 millimeters of mercury.

15.5.1.5 Place the vacuum manifold control in the **"high vacuum manifold"** position. The detectors are now at normal operating vacuum.

15.5.2 Venting Alpha Spectrometer model 7401 to Atmosphere

15.5.2.1 Ensure that the vacuum manifold control is set to the **"pump down manifold"** position.

15.5.2.2 Place the **"pump/vent"** valve/switch on the spectrometer in the **"vent"** position.

15.5.2.3 Repeat 15.5.2.2 for each chamber in the bank.

16.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

Refer to GL-RAD-I-010 Counting Room Instrument Maintenance.

17.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL

Refer to GL-RAD-D-003 Data Review, Validation, and Data Package Assembly.

18.0 POLLUTION/CONTAMINATION

Not applicable.

19.0 DATA RECORDING, CALCULATIONS, AND REDUCTION METHODS

Data recording, calculation, and reduction take place in accordance with GL-RAD-D-003 and GL-RAD-D-006.

20.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA

Corrective action for out-of-control data might require instrument maintenance, re-analysis, using a new spike mix, or a more complex set of actions. When trouble-shooting measures fail to bring an analytical process or data into control, a Data Exception Report (DER) and/or corrective action should be initiated in accordance with AlphaLIMS Documentation of Nonconformance Reporting and Dispositioning and Control of Nonconforming Items, GL-QS-E-004 and/or Conducting Corrective/Preventive Action and Identifying Opportunities for Improvement, GL-QS-E-002.

21.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS

Troubleshooting the instrument is a function of analyst experience. In-house service is obtained from GEL's Group Leader or other qualified personnel. If vendor assistance is needed, then the appropriate vendor is contacted. Maintenance logbooks are kept for each instrument and contain entries for both routine and non-routine maintenance procedures.

22.0 RECORDS MANAGEMENT

22.1 Each sample analysis that is performed is documented in the instrument run log in accordance with GL-LB-E-009 Run Logs.

22.2 All raw data printouts, calculation spreadsheets and batch checklists are filed with the sample data for archival in accordance with GL-RAD-D-003 Data Review, Validation, and Data Package Assembly.

22.3 Instrument maintenance is recorded in accordance with GL-LB-E-008, Basic Requirements for the Use and Maintenance of Laboratory Notebooks, Logbooks, Forms and Other Recordkeeping Devices.

23.0 LABORATORY WASTE HANDLING AND WASTE DISPOSAL

Refer to GL-LB-G-001 Laboratory Waste Management Plan.

24.0 REFERENCES

24.1 1990 Annual Book of ASTM Standards, Volume 12.02, E181.

24.2 Canberra Model 7401 Alpha Spectrometer Operations Manual.

24.3 U.S. Department of Energy Quality Systems for Analytical Services (DOE QSAS), Revision 2.8, January 2012

24.4 Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP), Chapter 18, July 2004

24.5 American Society for Testing and Materials (ASTM), ASTM C 1128-01(2008) and C1159-03 (2003).

24.6 National Institute of Science and Technology (NIST), Technical Note 1297, 1994.

25.0 HISTORY

Revision 15: Updated to correct grammatical errors as well as for formatting issues.
Revision 14: Updated to comply with current process as part of annual review.
Revision 13: Added reference note for the preparation of calibration sources for alphaspectrometer. Removed guidelines for the preparation and recertification of rare-earth fluoride efficiency sources for alpha spectrometry.
Revision 12: Added section for processing samples via AlphaGEL.
Revision 11: Annual review: Updated SOP throughout.

APPENDIX 1: TROUBLESHOOTING

Symptom	Possible Cause	Solution
Vacuum light on Alpha Analyst pair continuously blinks (beyond normal pump down time)	Vacuum pump oil low	Check the oil level on the vacuum pump and fill if necessary.
	Debris on vacuum seal of door	From the AMS Procedure window, select **Count** then **Pause Acquire**. Select **AA** then **Vent Chambers**. Open both chambers & clean the seal with a dry lint free cloth. Close the chambers. From the AMS Procedure window, select **AA** then **Pump Chambers**. Select **Count** then **Unpause Acquire**.
Acquisition of Alpha Analyst detector paused	Chamber was manually paused	From the AMS Procedure window, select **Count** then **Unpause Acquire**. Enter the detector to unpause.
	Vacuum leak to chamber	See "Vacuum light on Alpha Analyst pair continuously blinks" for possible solutions.
	Electronic fault	Check to see if the "fault" light on the detector is on, if so, abort acquisition by selecting **Count** then **Abort Acquire** from the AMS Procedure window for the effected chambers. Restart the count in accordance with section 14.1, 14.5, 14.9, or 15.1 as appropriate.
Buttons and/or switches on model 7401 detector do not appear to be functioning	Multiple causes	Reset chamber by simultaneously pressing RESET and DIGIT SELECT and move the INC/DEC switch to INC. Release the buttons & switch when the display goes blank.
Apparent poor vacuum (7401 only) indicated by display (above 800 µm Hg) or vacuum gauge	Vacuum sensor of chamber is bad	If the majority of other detectors on the same vacuum pump indicate a proper vacuum, the vacuum sensor in the detector is likely malfunctioning. This will not hinder detector operation.
	Vacuum pump oil low	Check the oil level on the vacuum pump and fill if necessary.
	Debris on vacuum seal of door	Attempt to isolate the bank where the poor seal is by putting manifold controls to hold position for each bank on the same pump to see if the vacuum shows improvement. Once a specific bank is isolated, use the chamber vacuum controls to further isolate the individual chamber. Once a single chamber is isolated as the cause, open the chamber & clean the seal with a dry lint free cloth. Restart the count of the affected bank.

	Manifold valve leaking	Attempt to isolate the bank where the leak is by putting manifold controls to hold position for each bank on the same pump to see if the vacuum shows improvement. Once a specific bank is isolated, check that the seal of the manifold valve is tight. Remove the valve lever by loosening the screw under the larger end & tighten the nut around the manifold valve. Be sure the nut is not so tight that the valve cannot be turned. Replace the valve lever.
	Leaking or cracked vacuum hose	Inspect hoses for loose connections or cracks. Replace cracked hose if necessary. If seal is loose, tighten hose clamp and/or add vacuum grease.
	Cracked or worn vacuum connection inside chamber	This problem involves working close to the electronics inside a 7401 detector. Consult the Group Leader (or designee) regarding repair of this condition.
Vacuum control knob loose (7401 only)	Alan screw loose	Using an alan wrench, tighten the two screws inside the knob.
DECterm window is not displayed	Window closed or computer was restarted	Open a new DECterm window from the Session Manager toolbar by selecting **Applications** then **DECterm**.
AMS Procedure window is not displayed	Window closed or computer was restarted	Open a new AMS workspace from the Spectroscopy Assistant window by selecting **File** then **Open Workspace**. Select the file **HUME.WSP** then click **OK**.
Spectroscopy Assistant window is not displayed	Window closed or computer was restarted	Open a new Spectroscopy Assistant window from the Session Manager toolbar by selecting **Applications** then **AMS Spec. Assistant**.

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE

FOR

COUNTING ROOM INSTRUMENTATION MAINTENANCE

(GL-RAD-I-010 REVISION 20)

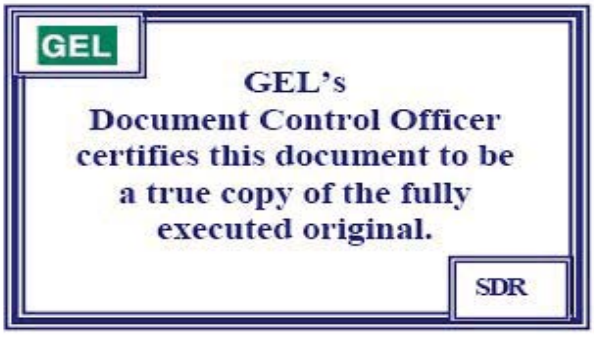

TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR COUNTING ROOM INSTRUMENTATION MAINTENANCE 3
2.0 PURPOSE 3
3.0 DISCUSSION 3
4.0 DEFINITIONS 3
5.0 PROCEDURES 3
6.0 SAFETY, HEALTH, AND ENVIRONMENTAL HAZARDS 8
7.0 RECORDS MANAGEMENT 8
8.0 REFERENCES 8
9.0 HISTORY 8

1.0 STANDARD OPERATING PROCEDURE FOR COUNTING ROOM INSTRUMENTATION MAINTENANCE

2.0 PURPOSE

This procedure outlines the routine maintenance for each of the counting room instruments.

3.0 DISCUSSION

In order to assure the optimum performance of counting room instrumentation, it is necessary to perform routine maintenance. The routine maintenance provides a means of maintaining instrument performance while minimizing the "down time" due to instrument failure and subsequent repair.

4.0 DEFINITIONS

4.1 AlphaLIMS: The Laboratory Information Management System used at GEL Laboratories, LLC.

4.2 Routine Maintenance: Any operation performed on an instrument to prevent premature equipment failure or to eliminate or minimize instrument contamination.

5.0 PROCEDURES

5.1 Gamma Spectrometers

5.1.1 Liquid nitrogen fill – Each detector must be kept cold to ensure proper operation. Keeping the Dewars filled with liquid nitrogen does this.

5.1.1.1 Safety precautions – Due to the nature of liquid nitrogen (approximately -320° F) safety goggles and cryogenic gloves are recommended. Also, when the Dewars vent, nitrogen gas can displace oxygen in the air. Before filling, open the main door between the count room and the Prep Laboratory to increase the flow of air into the count room. Oxygen monitors are present in the count room. If any of the alarms on the monitors are triggered, leave the area and contact the Group Leader or other designated personnel for further instructions.

5.1.1.2 Dewar fill – Three stages of valves are used in the Dewar fill procedure: the main count room valve, the line valves, and the individual detector valves. Once the fill has begun, one individual detector valve on a line must always be open to ensure that pressure does not build up in the pipes. To begin, open the line valve and the individual valves for any detectors to be filled. Close the line valves for the detectors that are not going to be filled. Open the main valve to begin allowing liquid nitrogen to fill the lines.

5.1.1.3 Finishing the Dewar fill – As the Dewars fill (indicated by liquid nitrogen exiting from the exhaust hoses on the

Dewars) close off their valves until only one valve remains on a line. Once the last Dewar on a line is filled, do not close off that individual valve. Instead, close off the line valve. If only one line valve remains open with only one Dewar left to fill, do not close off the line valve or the individual valve. Instead, close off the main count room valve. This will ensure that a closed pressure system is not created.

5.1.1.4 Wait a minimum of one hour to resume counting to allow the detectors to adjust and to minimize any thermal excitation that may occur from the Dewar fill.

5.1.2 Software Backups – Refer to section 5.6 for VMS backup system.

5.2 Alpha Spectrometry System

5.2.1 Software Backups – Refer to section 5.6 for VMS backup system.

5.2.2 Vacuum Pump Oil – The oil in the alpha spectrometry system vacuum pumps shall be changed as a minimum of semi-annually.

5.2.3 Filter Cleaning – The filter on the air intake of the instrument cabinet shall be cleaned as a minimum quarterly.

5.3 Gas Flow Proportional Counters

5.3.1 Software Backups – Data are archived on a remote server that is backed up/maintained by the CST Department.

5.3.2 Sample Shelf Cleaning – The sample shelf assembly should be cleaned periodically to minimize the accumulation of contamination. This is best performed prior to running the weekly and/or daily backgrounds.

5.4 Liquid Scintillation Counter

Sample Changer Cleaning – The sample changer assembly should be vacuumed or wiped out periodically to minimize the accumulation of dust in the instrument.

5.5 Lucas Cell Counters

PMT Cleaning – On a weekly basis, the window of the PMT shall be cleaned with glass cleaner to reduce the interference from dust accumulation.

5.6 VMS backup system

5.6.1 Software Backups – On a daily basis, the sample analysis records and any software changes on the workstation data disk are backed up to a remote server that is backed up/maintained by the CST Department.

5.6.1.1 To restore files from the backup storage locations, submit a request via the CST Help Desk.

5.6.2 System Hard Drive Backup and Crash Recovery – The operating system hard drive (typically DKA0:) shall periodically be backed up to a reserve hard drive.

5.6.2.1 Backup and restoration of the operating system hard drive shall only be done by qualified personnel.

5.6.2.2 A backup shall be made at a minimum of every 180 days, whenever significant changes are made to the software on the operating system drive, or whenever the system hard drive is replaced.

5.6.2.3 Backing up the system drive

5.6.2.3.1 Ensure that no instruments are acquiring data.

5.6.2.3.2 Verify volume label for the system drive.

5.6.2.3.3 Perform a controlled system shut down.

5.6.2.3.4 Turn off the VMS system.

5.6.2.3.5 Install a spare SCSI hard drive.

5.6.2.3.6 Boot the system with an operating system CD.

5.6.2.3.7 Select the option to execute DCL commands and procedures.

5.6.2.3.8 Mount the system drive.

5.6.2.3.9 Initialize the backup drive with the same volume name as the system drive.

5.6.2.3.10 Mount the backup drive using the /foreign qualifier.

5.6.2.3.11 Execute the following command – **backup/image 'source' 'destination'**, where 'source' is the system drive (usually dka0:) and 'destination' is the backup drive.

5.6.2.3.12 When the backup is complete, shut down the system, disconnect the spare drive, and restart the system.

5.6.2.3.13 Label the spare drive as **'system' system drive backup 'date'**, where 'system' is the name of the system and 'date' is the date the backup was done. Store this drive in a safe location.

5.6.2.4 Recovering from a system drive crash

5.6.2.4.1 If possible, perform a controlled system shut down.

5.6.2.4.2 Turn off the VMS system.

5.6.2.4.3 Replace the defective system drive with the most recent system drive backup. The backup

drive should be set to the same SCSI id as the drive being replaced.

5.6.2.4.4 Perform a backup of the new system drive as specified in section 5.6.2.3.

5.6.2.4.5 Restart the system.

5.6.3 Data Hard Drive Backup and Crash Recovery – On a weekly basis, the sample analysis records and any software changes on the workstation data disk (typically DKA100:) are automatically synchronized to a secondary hard drive in the system (typically dka200:).

5.6.3.1 Backing up the data drive - The data drive is automatically backed up on a weekly basis. No user interaction is required for this.

5.6.3.2 Recovering from a data drive crash

5.6.3.2.1 Restoration of the data drive shall only be done by qualified personnel.

5.6.3.2.2 If possible, perform a controlled system shut down.

5.6.3.2.3 Turn off the VMS system.

5.6.3.2.4 Remove the defective data drive from the system.

5.6.3.2.5 Set the SCSI id of a spare drive to that of the secondary drive.

5.6.3.2.6 Change the SCSI id of the secondary data drive to that of the defective drive.

5.6.3.2.7 Install the spare drive as a new secondary drive.

5.6.3.2.8 Boot the VMS system and log in as system administrator.

5.6.3.2.9 Copy data from the network backup that was saved since the last synchronization to the data drive with the following command – **copy/log/modified/replace/since='dd-mmm-yyyy' dnfs3:[000000…]*.*;* 'datadrive'[*]*.*;*,** where 'dd-mmm-yyyy' is the date of the last synchronization and 'datadrive' is the name of the data drive (typically dka100:).

5.6.3.2.10 Initialize the new secondary drive with the same volume name as the data drive.

5.6.3.2.11 Log off the system administrator account and log in as the operator.

5.6.3.2.12 An immediate backup of the data drive should be performed by entering the command **@backupdatadrive.**

5.7 Restoring VMS Backup access after server archive

5.7.1 Periodically, the VMS backup on the server shall be archived to tape and the data removed from the server. The Computer Services Team (CST) controls the periodicity and completion of this backup. CST personnel will inform the appropriate Group Leader or designee when this operation is performed.

5.7.2 For the backup to continue operating properly, the following must be completed on each VMS system.

5.7.2.1 Log into VMS system as system administrator.

5.7.2.2 Type **search systartup_vms.com dnfs**. This will display a line showing how the backup is mounted. The last part of the line (following "backup2/") is the backup folder for the system.

5.7.2.3 Using a PC, recreate the backup folder (all lowercase letters). Set the security privileges for the new folder to allow full access.

5.7.2.4 On the VMS system, dismount the backup drive with 'dismount dfns3:'

5.7.2.5 Remount the drive using the exact same command found in the search from step 5.7.2.2.

5.7.2.6 Example of the above:

5.7.2.6.1 SYSMGR> search systartup_vms.com dnfs3
$TCPIP mount dnfs3: /system/host = "backsvr" /path="/mnt01/backup2/env_alpha"

(Using a PC create the folder \\linuxsvr05\rad_backup\env_alpha and set permissions)

SYSMGR> dismount dnfs3:

SYSMGR> TCPIP mount dnfs3:/system/host= "backsvr"/path= "/mnt01/backup2/env_alpha"
%TCPIP$DNFSMOUNT-S-MOUNTED, /mnt01/backup2/env_alpha mounted on _DNFS3:[000000]

5.7.2.7 Log off the administrator account and return to the standard user (for bioassay alpha spec, use bio_alpha).

5.7.2.8 Enter the command **copy/log dka100:[000000]*.dir; * dnfs3:[000000]*.dir;*** and wait for it to complete.

5.7.2.9 Enter the command **copy/log dka100:[000000…]*.dir; * dnfs3:[*]*.dir;*** and wait for it to complete.

5.7.2.10 Edit the file last_backup.lis (last_backup.list on gamma spec.) and change the date to when the tape archive of the server was made or earlier if desired.

6.0 SAFETY, HEALTH, AND ENVIRONMENTAL HAZARDS

6.1 Personnel performing this analytical procedure are trained to the safe laboratory practices outlined in the Safety, Health, and Chemical Hygiene Plan, GL-LB-N-001.

6.2 Personnel handling radioactive materials are trained in and follow the procedures outlined in GL-RAD-S-004 for Radioactive Material Handling.

6.3 Personnel handling biological materials are trained in and follow the procedures outlined in GL-RAD-S-010 for The Handling of Biological Materials.

6.4 If there is any question regarding the safety of any laboratory practice, **stop immediately**, and consult qualified senior personnel such as a Group or Team Leader.

6.5 Wear cryogenic gloves whenever working with liquid nitrogen. When liquid nitrogen is dispensed in the count room, leave doors open to provide proper ventilation.

7.0 RECORDS MANAGEMENT

All raw data, calculation spreadsheets, and batch checklists are filed with the sample data and maintained as quality records in accordance with GL-QS-E-008 for Quality Records Management and Disposition.

8.0 REFERENCES

None

9.0 HISTORY

Revision 20: Updated backup process.

Revision 19: Replaced Weekly liquid nitrogen fill with liquid nitrogen fill in section 5.1.1.

Revision 18: Added new procedures to be used when data is archived from the server.

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE FOR MANAGING STATISTICAL DATA IN THE RADIOCHEMISTRY LABORATORY

(GL-RAD-I-012 REVISION 26)

PROPRIETARY INFORMATION

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TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR MANAGING STATISTICAL DATA IN THE RADIOCHEMISTRY LABORATORY 3
2.0 PURPOSE 3
3.0 DISCUSSION 3
4.0 DEFINITIONS 3
5.0 PROCEDURES 3
6.0 SAFETY, HEALTH AND ENVIRONMENTAL HAZARDS 9
7.0 RECORDS MANAGEMENT 9
8.0 REFERENCES 9
9.0 HISTORY 10

APPENDIX 1 11

1.0 STANDARD OPERATING PROCEDURE FOR MANAGING STATISTICAL DATA IN THE RADIOCHEMISTRY LABORATORY

2.0 PURPOSE

This procedure provides guidelines on how statistical limits utilized for the verification of instrument performance are derived and used at GEL Laboratories, LLC.

3.0 DISCUSSION

Verification of the operational performance of instrumentation is critical in the production of quality radioanalytical data. Statistical data is used to determine acceptable limits, identify trends and provide other useful information. Performance checks shall be performed using appropriate check sources and monitored with control charts or tolerance charts to ensure that the instrument is operating properly, the detector response has not significantly changed and therefore the instrument calibration has not changed. The same check source used in the preparation of the tolerance or control chart at the time of the calibration should be used in the calibration verification of the instrument.

4.0 DEFINITIONS

4.1 CPM: Counts per minute.

4.2 Detector Lockout: The result of a detector failing specific performance checks causing the detector to be removed from service.

4.3 FWHM (Full width at half maximum): A measure of the resolution of a peak width at half the maximum height of the peak.

4.4 AlphaLIMS: GEL Laboratories, LLC Laboratory Information Management System

5.0 PROCEDURES

5.1 Appendix 1 gives the instrument parameters that are monitored in the Radiochemistry Counting Laboratory. The limits for these parameters are established using one of two principal mechanisms:

5.1.1 Control Charts are established by running at least 10 replicates of the given test and then calculating the mean and standard deviation. The appropriate limits are based on the standard deviation of the data set. These established limits are static until the next statistical evaluation is performed, as determined by the Group or Team Leader.

5.1.2 Tolerance Charts are established setting a fixed upper and lower boundary level. These limits are based on well-established performance specifications and cannot be more restrictive than control chart statistical limits.

5.2 The following guidelines are used to evaluate the detectors in the laboratory for all instruments that use a database to evaluate their statistical data:

A “detector lockout” occurs if the measured value is outside the limits specified in Appendix 1. The detector will be locked out until the cause of the status is investigated and a performance check is completed within tolerance. The investigation will include review of the applicable control

and/or tolerance charts for the identification of trends. Should a trend be noted, the need for any corrective action will be discussed with the Group/Team Leader and documented in the instrument maintenance logbook. The review of out of specification parameters should include the review of the instrument performance from the previous day. In addition, a review of any data generated on the out of specification instrument, from the previous day, should be evaluated to determine if it was impacted by the out of specification parameter(s).

5.3 Gas Flow Proportional Counters

5.3.1 Daily Efficiency Checks– Separate alpha and beta emitting radioactive sources are counted each day the detector is used. The alpha and beta sources are counted separately until a minimum of 2,000 counts are accumulated.

5.3.2 Daily Background Checks - A background planchet is counted for 60 minutes each day that the detector is used. This value is used to monitor instrument contamination and is typically not used for background correction of sample analyses. An administrative cap on the allowable background is 0.3 cpm alpha and 2 cpm beta.

5.3.3 Weekly Environmental Backgrounds - Each week an environmental background is collected for the purpose of background correcting sample analyses. The normal weekly backgrounds are counted for 500 minutes. Once per month the weekly background is collected for 1000 minutes. The weekly background checks are included with the daily background checks in the determination of statistical limits for control charts. An administrative cap on the allowable background is 0.3 cpm alpha and 2 cpm beta.

5.3.4 If the instrument checks are outside the established limits list in Appendix 1, the failed check should be immediately re-run according to the steps listed below. Once checks are completed, the appropriate logout sign will be placed on the locked out detectors. The instrument can be returned to service, after being locked out, following two successful instrument checks.

5.3.5 Weekly Background Failure

5.3.5.1 Low Background: Run the daily efficiency check

5.3.5.1.1 If the efficiency check passes, approve for use.

5.3.5.1.2 If the efficiency check fails, notify the Team Leader or Group Leader for further review.

5.3.5.2 High Background: Notify the Team Leader or Group Leader for review.

5.3.6 Daily Background Failure

5.3.6.1 Low Background: Run the daily efficiency check

5.3.6.1.1 If the efficiency check passes, approve for use.

5.3.6.1.2 If the efficiency check fails, notify the Team Leader or Group Leader for further review.

5.3.6.2 High Background: Recount the daily background check

5.3.6.2.1 If the 2nd count fails, notify Team Leader or Group Leader for further review.

5.3.6.2.2 If the 2nd count passes, count a 3rd time to determine the validity of the second count.

5.3.6.2.2.1 If the 3rd count passes, approve for use.

5.3.6.2.2.2 If the 3rd count fails, notify Team Leader or Group Leader for further review.

5.3.7 Daily Efficiency Failure

5.3.7.1 Low or High Efficiency-Ensure that the correct daily check source is in use and positioned correctly in the detector. Re-run the efficiency check.

5.3.7.1.1 If the 2nd count fails, notify Team Leader or Group Leader for further review.

5.3.7.1.2 If the 2nd count passes, count a 3rd time to determine the validity of the 2nd count.

5.3.7.1.2.1 If the 3rd count passes, approve for use.

5.3.7.1.2.2 If the 3rd count fails, notify Team Leader or Group Leader for further review.

5.4 Liquid Scintillation Counters

5.4.1 Daily instrument checks - A sealed, unquenched Tritium (H-3), Carbon-14 (C-14) and background vial are counted each day to verify instrument performance. The radioactive source is counted for a minimum of 20,000 counts, and the background is counted twice daily for a minimum of 30 minutes each instance.

NOTE: These background values are used to monitor instrument contamination and are not used for background correction of sample analyses.

5.4.2 If the instrument checks are outside the established limits list in Appendix 1, the failed check should be immediately re-run according to the steps listed below. Once the checks are completed, the appropriate logout sign will be placed on the locked out detectors. The instrument can be returned to service, after being locked out, following two successful instrument checks.

5.4.3 Daily Background Failure

5.4.3.1 Low background: Run the daily efficiency check

5.4.3.1.1 If the efficiency passes, approve for use.

5.4.3.1.2 If the efficiency check fails, notify the Team Leader or Group Leader for further review.

5.4.3.2 High Background: Recount the daily background check

5.4.3.2.1 If the 2nd count fails, notify the Team Leader or Group Leader for further review.

5.4.3.2.2 If the 2nd count passes, count a 3rd time to determine the validity of the 2nd count.

5.4.3.2.2.1 If the 3rd count passes, approve for use.

5.4.3.2.2.2 If the 3rd count fails, notify Team Leader or Group Leader for further review.

5.4.4 Daily Efficiency Failure

5.4.4.1 Low or High Efficiency- Ensure that the correct daily check source is in use and positioned correctly in the rack. Re-run the efficiency check.

5.4.4.1.1 If the 2nd count fails, notify Team Leader or Group Leader for further review.

5.4.4.1.2 If the 2nd count passes, count a 3rd time to determine the validity of the 2nd count.

5.4.4.1.2.1 If the 3rd count passes, approve for use.

5.4.4.1.2.2 If the 3rd count fails, notify Team Leader or Group Leader for further review.

5.5 Alpha Spectrometers

5.5.1 Daily Pulser Checks - A daily pulser check is run on each detector that is to be used for analyzing samples that day. The pulser is an electronic signal typically set at 5 MeV. If the instrument checks are outside the established limits listed in Appendix 1, the failed check should be immediately rerun. If the check fails a second time the instrument is locked out of service and the cause investigated. The instrument status board will be updated to reflect the lockout condition and a logbook entry will be made. The instrument can be returned to service following two successful instrument checks.

5.5.2 Weekly Backgrounds - Once per week a background of at least 1000 minutes is counted on each detector. The background spectra is processed with each individual isotopic region of interest. If the instrument background checks are outside the established limits list in Appendix 1 for any isotope, the instrument status board will be updated to reflect the lockout condition for that particular isotope/detector. The lockout condition can be cleared following two successful background checks.

5.5.3 Monthly Calibrations - Monthly, a calibrated mixed alpha source consisting of Gd-148, Cm-244 and Np-237 is counted on each detector. The standards are used to calibrate for both energy and efficiency and to monitor the instrument performance. The analysis data is compared to the limits in Appendix 1. In the event an Alpha Spectrometer parameter is determined to be outside of the control boundaries, the status board shall be updated to reflect the "out of service" condition for that instrument and a logbook entry shall be made. The condition should be investigated and the instrument may be returned to service following two successful instrument checks and/or calibrations.

5.6 Gamma Spectrometers

5.6.1 Weekly Background Count - Once per week a background of at least 1000 minutes is counted on each detector. This count is used to subtract the background counts from sample counts. Occasionally a geometry-specific background count may be counted as needed. This is done in addition to the weekly background count and may be used for any sample counted within 1 calendar month of it. Below are the guidelines for handling any failures of the weekly background:

5.6.1.1 High background-Notify the Team Leader or Group Leader for further review.

5.6.1.2 Low background-Run the daily efficiency check.

5.6.1.2.1 If the calibration check passes, approve for use.

5.6.1.2.2 If the calibration check fails, notify the Team Leader or Group Leader for further review.

5.6.2 Daily Background Check – A 15 minute quality control count performed at least once per day a detector is in operation. This count is used to monitor contamination and is not used for background subtraction. Below are the guidelines for handling any failures.

5.6.2.1 High background-recount the daily background check

5.6.2.1.1 If the 2nd count fails, notify Team Leader or Group Leader for further review.

5.6.2.1.2 If the 2nd count passes, count a 3rd time to ensure the validity of the 2nd count.

5.6.2.1.2.1 If the 3rd count passes, approve for use.

5.6.2.1.2.2 If the 3rd count fails, notify the Team Leader or Group Leader for further review.

5.6.2.2 Low background-Run the daily efficiency check

5.6.2.2.1 If the efficiency check passes, approve for use.

5.6.2.2.2 If the efficiency check fails, notify the Team Leader or Group Leader for further review.

5.6.3 Daily Efficiency Checks – A mixed gamma standard is counted daily or prior to sample analyses. Three lines are chosen and monitored typically Am-241 at 59.5 keV, Cs-137 at 661.6 keV, and Co-60 at 1332.5 keV. For low energy detectors, such as X-ray detectors, different nuclides are chosen. The parameters monitored can be found in appendix 1 of this procedure. This is used to monitor instrument performance.

5.6.3.1 Decay corrected activity – Ensure the daily check source was positioned properly on the detector and the detector itself is positioned properly and recount.

5.6.3.1.1 If the 2nd count fails, notify the Team Leader or Group Leader for further review.

5.6.3.1.2 If the 2nd count passes, recount a 3rd time to ensure the validity of the 2nd count.

5.6.3.1.2.1 If the 3rd passes, approve for use.

5.6.3.1.2.2 If the 3rd count fails, notify the Team Leader or Group Leader for further review.

5.6.3.2 Peak FWHM – Ensure the detector is positioned properly and recount.

5.6.3.2.1 If the 2nd count fails, notify the Team Leader or Group Leader for further review.

5.6.3.2.2 If the 2nd count passes, count a 3rd time to ensure the validity of the 2nd count.

5.6.3.2.2.1 If the 3rd count fails, notify the Team Leader or Group Leader for further review.

5.6.3.2.2.2 If the 3rd count passes, approve for use.

5.6.3.3 Peak energy – Ensure the daily check source and detector are positioned correctly and re-analyze the efficiency check.

5.6.3.3.1 If the 2nd count fails, notify the Team Leader or Group Leader for further review.

5.6.3.3.2 If the 2nd count passes, recount a third time to confirm the validity of the 2nd count.

5.6.3.3.2.1 If the 3rd count fails, notify the Team Leader or Group Leader for further review.

5.6.3.3.2.2 If the 3rd count passes, approve for use.

5.7 Lucas Cells

5.7.1 Daily Efficiency Check - Each day a daily check is counted for 1 minute on each detector that is to be used for analysis. The standard is a nominal source standard of Radium-226 sealed in a Lucas cell. If the instrument checks are outside the established limits list in Appendix 1, the failed check should be immediately re-run according to the steps listed below. Once the checks are completed, the appropriate logout sign will be placed on the locked out detectors and a logbook entry made. The instrument can be returned to service after being locked out following two successful instrument checks.

5.7.1.1 Daily Efficiency Failure

5.7.1.1.1 Low or High Efficiency – ensure that the correct daily check source is in use and positioned correctly. Re-run the efficiency check.

5.7.1.1.2 If the 2nd count fails, notify Team Leader or Group Leader for further review.

5.7.1.1.3 If the 2nd count passes, count a 3rd time to determine the validity of the 2nd count.

5.7.1.1.3.1 If the 3rd count passes, approve for use.

5.7.1.1.3.2 If the 3rd count fails, notify Team Leader or Group Leader for further review.

6.0 SAFETY, HEALTH AND ENVIRONMENTAL HAZARDS

There are no specific safety requirements associated with the activity described in this procedure. Refer to the Safety, Health and Chemical Hygiene Plan (GL-LB-N-001) for basic safety and health information.

7.0 RECORDS MANAGEMENT

7.1 Each analysis that is performed on the instrument is documented in the run log in accordance with GL-LB-E-009 for Run Logs.

7.2 All raw data printouts, calculation spreadsheets and batch checklists are filed with the sample data and maintained as quality records.

8.0 REFERENCES

8.1 Chieco, N.A, Bogen, D.C., Knutson, E.O. Environmental Measurements Laboratory (EML) Procedures Manual. 28th Edition, Volume 1. US Department of Energy February 1997.

8.2 Krieger, H.L., Whittaker, E.L. Prescribed Procedures for Measurement of Radioactivity in Drinking Water. EPA 600 4-80-032. Environmental Monitoring and

Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. August 1980.

8.3 ANSI N42.23 "Measurement and Associated Instrument Quality Assurance for Radioassay Laboratories" July 1996.

8.4 ANSI N42.15 "Check Sources for and Verification of Liquid Scintillation Counting Systems" September 1997.

8.5 ANSI N42.14 "Calibration and Use of Germanium Spectrometers for the Measurement of Gamma-Ray Emission Rates of Radionuclides", May 1999.

8.6 ANSI N42.25 "Calibration and Usage of Alpha/Beta Proportional Counters, January 1997.

8.7 Dept. of Defense (DoD) , Dept. of Energy (DoE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, DoD QSM Version 5.0, DoE QSAS Version 3.0, July, 2013.

9.0 HISTORY

Revision 26: Step 5.3.1 changed from 50,000 counts to 2,000 counts per DoD/DoE QSM Table 18.

Revision 25: Updated section on weekly background count.

Revision 24: Replaced "Less than 3.0 keV(tolerance)" with "3 sigma" for Gamma spectrometer limit in appendix 1.

Revision 23: Updated section 5.6.3 to conform to the gamma instrument operation SOP.

Revision 22: Technical clarification made to section 5.2 for client specific requirements.

Revision 21: Updates made to clarify the process of handling QC failures for Gamma Spec and Alpha Spec instrumentation.

APPENDIX 1

Instrument	Parameter	Limit
Proportional counter	Daily Alpha Source check	3 Sigma
Proportional counter	Daily Beta Source Check	3 Sigma
Proportional counter	Daily alpha and beta crosstalk	3 Sigma
Proportional counter	Daily Background check	3 Sigma (0.3 cpm alpha max., 2.0 cpm beta max.)
Proportional counter	Weekly Background check	3 Sigma (0.3 cpm alpha max., 2.0 cpm beta max.)
Scintillation counter	Daily source check (H-3 and C-14)	3 Sigma
Scintillation counter	Daily background check	3 Sigma
Gamma spectrometer	Daily peak energy (using 3 energy lines)	Boundary +/- 2 keV (tolerance)
Gamma spectrometer	Daily peak FWHM (using 3 energy lines)	3 Sigma
Gamma spectrometer	Daily decay-corrected activity (using 3 energy lines)	3 Sigma
Gamma spectrometer	Daily background check-total spectrum counts	3 Sigma
Gamma spectrometer	Weekly background count-total spectrum counts	3 Sigma
Lucas cells	Daily Source Check	3 Sigma (tolerance)
Lucas cells	Daily Background Check	< 0.267 cpm (tolerance)

Instrument	Parameter	Standard Limit (See Note 1)	Initial Limit (See Note 2)
Alpha spectrometer	Daily pulser check FWHM	Boundary (1-35 keV)	
Alpha spectrometer	Daily pulser check peak centroid	Boundary (±15 channels of mean)	Boundary (±15 channels of initial average)
Alpha spectrometer	Daily pulser check peak energy	Boundary (±50 keV of mean)	Boundary (±50 keV of initial average)
Alpha spectrometer	Daily pulser check count rate	Boundary (±3% of mean)	Boundary (±3% of initial average)
Alpha spectrometer	Weekly Background check by isotopic region	Boundary (0.050 cpm) per region	
Alpha spectrometer	Monthly Cal. Energy Calibration Offset	Boundary (2300-2450 keV)	
Alpha spectrometer	Monthly Cal. Energy Calibration Slope	Boundary (4.7-5.3 keV/channel)	
Alpha spectrometer	Monthly Cal. Constant FWHM	Boundary (3-25 channels)	

Alpha spectrometer	Monthly Cal. Average Efficiency	3 Sigma std. deviation	Boundary (±.01 of initial average)
Alpha spectrometer	Monthly Cal. Peak Energy of 3 isotopes	Boundary (±40 keV of actual energy)	
Alpha spectrometer	Monthly Cal. Peak Resolution of 3 isotopes	Boundary (5-100 keV)	
Alpha spectrometer	Monthly Cal. Peak Area of 3 isotopes	Boundary (minimum 10,000 counts)	
Alpha spectrometer	Monthly Cal. Peak Activity of 3 isotopes	3 Sigma std. deviation	Boundary (±1% of initial average)

Note 1: Standard Limits are based on 3 Sigma and/or Mean and will be calculated on 20 reference points after an initial setup or repair/adjustment is made.

Note 2: Initial Limit is used when an instrument is initially set up or repaired/adjusted. These limits tend to have tighter boundaries than those used for 3 Sigma Standard Limit. Once 20 reference points are collected, the Standard limit will be calculated. Initial Averages are determined from the first 2 reference points.

VERIFY THE VALIDITY OF THIS SOP EACH DAY IN USE

STANDARD OPERATING PROCEDURE

FOR

MULTI-DETECTOR COUNTER

OPERATING INSTRUCTIONS

(GL-RAD-I-016 REVISION 10)

PROPRIETARY INFORMATION

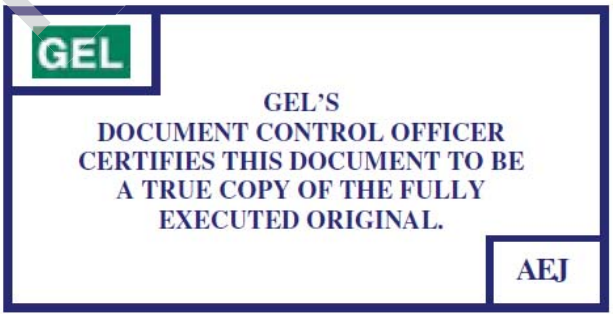

TABLE OF CONTENTS

1.0 STANDARD OPERATING PROCEDURE FOR MULTI-DETECTOR COUNTER OPERATING INSTRUCTIONS 3
2.0 METHOD OBJECTIVE, PURPOSE, CODE, AND SUMMARY (IDENTIFICATION OF TEST METHOD) 3
3.0 APPLICABLE MATRIX OR MATRICES 3
4.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT 3
5.0 METHOD VARIATIONS 3
6.0 DEFINITIONS 3
7.0 INTERFERENCES/LIMITATIONS 3
8.0 SAFETY PRECAUTIONS AND WARNING 3
9.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION 3
10.0 REAGENTS AND STANDARDS 4
11.0 SAMPLE HANDLING AND PRESERVATION 4
12.0 SAMPLE PREPARATION 4
13.0 QUALITY CONTROL SAMPLES 4
14.0 INSTRUMENTATION CALIBRATION, STANDARDIZATION AND PERFORMANCE 4
15.0 PROCEDURES 7
16.0 EQUIPMENT AND INSTRUMENT MAINTENANCE 8
17.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS 8
18.0 POLLUTION/CONTAMINATION 8
19.0 DATA REVIEW, APPROVAL AND TRANSMITTAL 8
20.0 CORRECTIVE ACTIONS FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA .. 8
21.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS 8
22.0 RECORDS MANAGEMENT 8
23.0 LABORATORY WASTE HANDLING AND DISPOSAL 9
24.0 REFERENCES 9
25.0 HISTORY 9

1.0 STANDARD OPERATING PROCEDURE FOR MULTI-DETECTOR COUNTER OPERATING INSTRUCTIONS

2.0 METHOD OBJECTIVE, PURPOSE, CODE, AND SUMMARY (IDENTIFICATION OF TEST METHOD)

This method describes the operation of the Multi-Detector Counting System for routine sample analysis. The operation includes access to the computer operating system, calibration, performance checks, initiating data collection, and printing data plots and reports.

3.0 APPLICABLE MATRIX OR MATRICES

This procedure is applicable to all matrices.

4.0 METHOD SCOPE, APPLICABILITY, AND DETECTION LIMIT

This procedure is not specific to one particular method. For method scope, applicability, or detection limit refer to the method specific analytical standard operating procedure.

5.0 METHOD VARIATIONS

Not Applicable.

6.0 DEFINITIONS

6.1 Check Source: A radioactive source, not necessarily calibrated, that is used to confirm the satisfactory operation of the instrument.

6.2 Crosstalk: The detection of alpha events in the beta channel or the detection of beta events in the alpha channel during simultaneous counting.

6.3 Efficiency: The percent of decay events from a standard source that are seen and measured by a detector.

6.4 Proportional Counter: A gas filled radiation counter tube operated in the range of high voltage in which the total charge collected for each ionizing event is proportional to the number of ion pairs formed in the tube by the initial event.

6.5 Self Absorption: Absorption of radioactive emissions by the solids contained on the counting planchet, thereby preventing the emission from reaching the detector.

6.6 Simultaneous Counting: The measurement of both gross alpha and gross beta activity at the same time.

7.0 INTERFERENCES/LIMITATIONS

For analyses requiring isotope specific analyses (i.e. Cl-36, Sr-90), chemical separations are performed during sample preparation to remove unwanted counting interferences.

8.0 SAFETY PRECAUTIONS AND WARNING

There are no specific safety requirements associated with the activity described in this procedure. Refer to GL-LB-N-001, the Safety, Health, and Chemical Hygiene Plan, for basic safety and health information.

9.0 APPARATUS, EQUIPMENT, AND INSTRUMENTATION

9.1 Protean Multi-detector Gross Alpha/Beta Counting System.

9.2 Printer

9.3 Gas Regulator, recommended a dual stage regulator

9.4 Radioactive Check Source, containing an alpha and/or beta emitting isotope(s). The actual isotope is dependent on the radionuclide to be measured. Normally a Sr-90/Y-90 or Th-230 source is used.

9.5 Traceable Calibration Standard: NIST traceable standard based upon the isotope to be measured

9.6 P-10 Gas (90% Argon/10% Methane)

10.0 REAGENTS AND STANDARDS

Not Applicable.

11.0 SAMPLE HANDLING AND PRESERVATION

Not Applicable.

12.0 SAMPLE PREPARATION

Refer to appropriate sample preparation procedure.

13.0 QUALITY CONTROL SAMPLES

Refer to GL-RAD-D-003 for Data Review, Validation, and Data Package Assembly.

14.0 INSTRUMENTATION CALIBRATION, STANDARDIZATION, AND PERFORMANCE

14.1 Calibration of the instrument shall be performed at initial installation. The calibration will be reestablished and/or reverified on an annual frequency, after changing detectors, following system maintenance that may affect the electronics, or when a problem is suspected. The instrument's window settings should not be changed after the initial set up. If the window settings are altered, all calibrations for the instrument must be renewed.

NOTE: For Drinking Water Compliance Monitoring-If a gas proportional counter is moved, serviced, or had an interruption in either gas flow or electrical power, the plateau voltage for both alpha and beta is verified, its crosstalk factors remeasured, and the solids absorption curves for each analyte reverified or regenerated prior to measuring any compliance monitoring samples.

NOTE: Expiration dates will match the last day of the month in which the calibration data was acquired.

NOTE: After initial Plateau generation, the regeneration of a Plateau to determine the Operating Voltage is not required, unless indicated by instrument response or performance as determined through daily performance checks, control charts, and calibration verifications (ANSI N42.25). If a generation of a Plateau is not required, proceed to step 14.2 of this calibration section.

14.1.1 Determining the operating voltage:

The operating voltage of the instrument is determined by performing a plateau. The plateau is performed by counting a Sr-90 source long

enough to achieve 10,000 counts. The source is repeatedly counted as the voltage of the instrument is increased.

14.1.2 Performing a Plateau

14.1.2.1 Load a Sr-90 source into each one of the instruments that is to be calibrated.

14.1.2.2 Click on the appropriate instrument box on the instrument software. (i.e. To start a plateau for detectors 1A, 1B, 1C, 1D click on the box labeled instrument 1)

14.1.2.3 Select "instrument" from the software's toolbar, and choose bias selection.

14.1.2.4 In the pop-up window, click on the start button to run the plateau. Once the plateau has been completed, the data may be printed and graphed. The optimum operation voltage for beta counting is approximately 30-150 volts above the knee of the curve. The knee is determined by drawing straight lines along the rising slope and the plateau portions of the curve; the knee is the point where these two lines intersect. The operating voltage is typically the first point on the plateau (flat portion of the curve). The plateau length should be at least 200 volts. The % slope per 100 volts should be <10% for distributed sources. This will yield good efficiency with the lowest background.

14.2 Source preparation for the crosstalk and efficiency determinations can be located in each isotopic SOP as each calibration is matrix/isotope specific.

14.3 Crosstalk determination:

Crosstalk determination is the measurement of alpha events in the beta channel or beta events in the alpha channel. Crosstalk is determined on an annual basis, usually coinciding with the gross alpha/beta calibration. These crosstalk values are used in all calibrations for the instrument.

14.3.1 Determining alpha crosstalk

Alpha crosstalk is the measurement of alpha events in the beta channel. The value is determined by counting a set of pure alpha emitting sources (Po-210), which should increase in mass similarly to calibration efficiency sources, long enough to achieve 10,000 total alpha counts each. The alpha crosstalk value is calculated by dividing the number of resulting beta counts by the number of resulting alpha counts. Source mass vs. %crosstalk should be plotted, and the coefficients of the curve should be used in calculating alpha crosstalk for all samples.

NOTE: For Drinking Water Crosstalk determination, Th-230 will be used to determine crosstalk values. The crosstalk values will be optimized using a Po-210 mass attenuation curve.

14.3.2 Determining beta crosstalk

Beta crosstalk is the measurement of beta events in the alpha channel. A set of Sr-90 sources should be counted in each detector, long enough to achieve 10,000 total beta counts. Beta crosstalk should be calculated for each source by dividing total alpha counts by total beta counts. An average of all of the sources crosstalk values should be calculated for each detector, and this average value will represent that detector's beta crosstalk.

14.4 Efficiency determination

An efficiency for each detector is determined per method. For Ra-228 in all matrices except drinking water, an average efficiency is determined for each detector. This is accomplished by counting a set of at least 4 identical sources in each detector long enough to achieve 10,000 total beta counts. Efficiency is calculated as cpm/dpm and an average of the efficiencies for each detector is determined. For all other methods counted on the instrument, a set of sources that increase in mass, is counted long enough to achieve 10,000 total counts for each source in the respective channel. Efficiency (cpm/dpm) is determined and plotted against the mass of the source. The coefficients of the plotted curve are used to determine efficiency per sample, corresponding to the sample's mass.

NOTE: For the above generated efficiency curves, each data point should be within 10% of the calculated value of the curve. If any data points exceed the acceptance criteria, the GL should be consulted for evaluation and possible exclusion of the outlier.

14.5 Efficiency verification

The determined efficiency of each detector for each calibration must be verified with an independent NIST traceable source prior to using the newly established efficiencies. The result of each verification source when calculated with the new efficiency must be ± 25% of the known value.

14.6 Weekly Checks

The instrument background is determined weekly using the same procedure as for the Daily Background Check (below) except it is counted for 500 minutes. Monthly, one of the weekly background counts will be extended to 1000 minutes. This will normally be done during the first week of a new month.

14.7 Daily Checks

14.7.1 Before counting samples, ensure that the daily QA and background checks have been completed and entered into AlphaLIMS.

14.7.1.1 Background Check: Confirm P-10 gas to instrument is between 0.1-0.3 (scfh). If not, contact group leader. Place a contamination free planchet into each detector holder. Using the mouse, double click the appropriate detector to begin its background count. A new window will appear. In that window, select "source log." From the drop down menu under sample id, highlight BKG. Enter 60 minutes in the field supplied for count time, and click the start button. Repeat this until all detector backgrounds are started.

14.7.1.2 Daily Efficiency Check – Place the prepared check sources in the appropriate holders. Follow the steps for starting a background count, except choose EFFA (for the alpha check source) or EFFB (for the beta check source). Count each assigned source (alpha and beta) for 5 minutes in each detector.

14.7.2 Uploading QA Data

14.7.2.1 Open Microsoft Excel. "Rad Menus" file should open automatically.

14.7.2.2 Click "GFPC Dailies" button.

14.7.2.3 Enter today's date into the "Enter Date for Daily Report" field. Data will be pulled for all GFPC instruments. This may take a few moments.

14.7.2.4 Enter today's date into the "Enter date to upload" field. Click "ok."

14.7.2.5 Print daily and scan daily sheet or sign electronically. Refer to GL-RAD-I-012, Managing Statistical Data in the Radiochemistry Laboratory, for guidance on locking out detectors.

15.0 PROCEDURES

15.1 Startup

The Multi-Detector is left in a running condition. The software program may be closed or left open. Start the Protean software by opening the PIC MDS Control Panel.

15.2 Starting a Count

15.2.1 Confirm P-10 gas to instrument is between 0.1-0.3 (scfh). If not, contact group leader.

15.2.2 Insert samples into counting unit and mark detector IDs in the appropriate area of the que sheet.

15.2.3 From the tool bar at the top of the monitor, click "log" and from the drop down menu select batch. Click the + button, and enter the batch #. Click the + button again.

15.2.4 From the tool bar at the top of the monitor, click "log" and from the drop down menu select sample. Click the + button and enter the sample ID. From the drop down menu, select the batch #. Repeat this for all loaded samples. When done, close the log window.

15.2.5 Double click on the detector ID to be started. Select the sample ID from the drop down menu, and enter the count time. Click start.

16.0 EQUIPMENT AND INSTRUMENT MAINTENANCE

Refer to GL-RAD-I-010, Counting Room Instrument Maintenance and Performance Checks.

17.0 DATA RECORDING, CALCULATION, AND REDUCTION METHODS

Refer to GL-RAD-D-003 for Data Review, Validation, and Data Package Assembly.

18.0 POLLUTION/CONTAMINATION

Not Applicable

19.0 DATA REVIEW, APPROVAL, AND TRANSMITTAL

Refer to GL-RAD-D-003 for Data Review, Validation, and Data Package Assembly.

20.0 CORRECTIVE ACTIONS FOR OUT-OF-CONTROL OR UNACCEPTABLE DATA

Corrective action for out-of-control data might require instrument maintenance, reanalysis, using a new spike mix, or a more complex set of actions. When troubleshooting measures fail to bring an analytical process or data into control, a Data Exception Report (DER) and/or corrective action should be initiated in accordance with GL-QS-E-004 for Documentation of Nonconformance Reporting and Dispositioning and Control of Nonconforming Items, and/or GL-QS-E-002 for Conducting Corrective/Preventive Action and Identifying Opportunities for Improvement.

21.0 CONTINGENCIES FOR HANDLING THESE SITUATIONS

Troubleshooting the instrument is a function of analyst experience. In-house service is obtained from GEL's group leader or other qualified personnel. If vendor assistance is needed, then the appropriate vendor is contacted. Maintenance logbooks are kept for each instrument and contain entries for both routine and non-routine maintenance procedures.

22.0 RECORDS MANAGEMENT

22.1 Each sample analysis that is performed is documented in the instrument run log in accordance with GL-LB-E-009 for Run Logs.

22.2 All raw data printouts, calculation spreadsheets, and batch checklists are filed with the sample data for archive in accordance with GL-RAD-D-003 for Data Review, Validation, and Data Package Assembly.

22.3 Instrument maintenance is recorded in accordance with GL-LB-E-008, Basic Requirements for the Use and Maintenance of Laboratory Notebooks, Logbooks, Forms, and Other Recordkeeping Devices.

23.0 LABORATORY WASTE HANDLING AND DISPOSAL

Refer to GL-LB-G-001, GEL's Laboratory Waste Management Plan.

24.0 REFERENCES

24.1 Protean Instruments Multi-detector System Operation Manual.

24.2 ANSI N42.26-1997 Calibration and Usage of Alpha/Beta Proportional Counters. **NOTE**: GEL incorporates this reference with the exception of section 6.5 for Effectiveness of the Guard detector which is not incorporated for use. The efficiency sources used in the calibration process typically achieve 10,000 gross counts and the sources used in the cross talk and verification process typically achieve 5,000 gross counts.

24.3 DOE Quality Systems for Analytical Services

25.0 HISTORY

Revision 5: Updated procedures for uploading QC data from GFPC instruments.

Revision 6: Updated section on instrument calibration for clarification.

Revision 7: Calibration clarification.

Revision 8: Updated for drinking water compliance monitoring to comply with DHEC certification extension requirements.

Revision 9: Updated to include drinking water crosstalk determination using Th-230 and Po-210.

Revision 10: Added NOTE to section 24.2.

Attachment 6
Laboratory Certifications

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

GEL LABORATORIES, LLC
2040 Savage Road
Charleston, SC 29414
Robert L. Pullano Phone: (843) 556-8171
rlp@gel.com

ENVIRONMENTAL

Valid To: June 30, 2017 Certificate Number: 2567.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.0 of the DoD Quality Systems Manual for Environmental Laboratories), accreditation is granted to this laboratory to perform the following radiochemical tests in various matrices, including soils, drinking water, wastewater, groundwater, fiber air filters, vegetation, animal tissues, milk and construction debris:

	Preparation SOP	**Analytical SOP**
Alpha Spectrometry: Alpha: Am-241, Am-243, Cf-252, Cm-242, Cm-243/244, Cm-245/246, Np-237, Po-208, Po-209, Po-210, Pu-236, Pu-238, Pu-239/240, Pu-241, Pu-242, Pu-244, Th-228, Th-229, Th-230, Th-232, U-232, U-233/234, U-235/236, U-238	GL-RAD-A-011, GL-RAD-A-016, GL-RAD-A-032, GL-RAD-A-035, GL-RAD-A-036, GL-RAD-A-038	GL-RAD-I-009
Radon Emanation: Ra-226	GL-RAD-A-008, GL-RAD-A-028	GL-RAD-I-007
Gamma Spectrometry: Gamma: 46 to 1836 keV, I-129, I-131, Ni-59	GL-RAD-A-006, GL-RAD-A-013, GL-RAD-A-022	GL-RAD-I-001
Kinetic Phosphorescence Analyzer: Total Uranium	GL-RAD-A-023	GL-RAD-B-018

	Preparation SOP	Analytical SOP
Gas Flow Proportional Counting:		
Alpha: Total Radium	GL-RAD-A-010, GL-RAD-A-044	GL-RAD-I-006, GL-RAD-I-015, GL-RAD-I-016
48 Hour Gross Alpha	GL-RAD-A-047	
Gross Alpha/Gross Beta	GL-RAD-A-001, GL-RAD-A-001B, GL-RAD-A-001C, GL-RAD-A-001D	
Beta: Cl-36, I-131, Pb-210, Ra-228, Sr-89, Sr-90	GL-RAD-A-004, GL-RAD-A-009, GL-RAD-A-017, GL-RAD-A-018, GL-RAD-A-029, GL-RAD-A-030, GL-RAD-A-033, GL-RAD-A-054, GL-RAD-A-058	
Liquid Scintillation Spectrometry:		
Gross Alpha/Gross Beta	GL-RAD-A-056	GL-RAD-I-004, GL-RAD-I-014,
Alpha: Rn-222	GL-RAD-A-007	GL-RAD-I-017
Beta: C-14, Ca-45, Fe-55, H-3, Ni-63, P-32, Pm-147, Pu-241, S-35, Se-79, Tc-99	GL-RAD-A-002, GL-RAD-A-003, GL-RAD-A-005, GL-RAD-A-019, GL-RAD-A-020, GL-RAD-A-022, GL-RAD-A-031, GL-RAD-A-035, GL-RAD-A-040, GL-RAD-A-048, GL-RAD-A-049, GL-RAD-A-050, GL-RAD-A-059	
Pyrolysis Preparation C-14, H-3 (Special Matrices)	GL-RAD-A-067	
ICP-MS:		
Uranium Isotopes, Tc-99	GL-RAD-A-005 GL-RAD-A-055	GL-RAD-B-034

Additionally, In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.0 of the DoD Quality Systems Manual for Environmental Laboratories), accreditation is granted to this laboratory to perform recognized EPA, Standard Methods for the Examination of Water and Wastewater, ASTM, California and Connecticut test methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Atomic Absorption/ICP-AES Spectrometry, ICP/MS, Gas Chromatography, Gas Chromatography/Mass Spectrometry, Gravimetry, High Performance Liquid Chromatography, Ion Chromatography, Methylene Blue Active Substances, Misc.-Electronic Probes (pH, O_2), Oxygen Demand, Hazardous Waste Characteristics Tests, Spectrophotometry (Visible), Spectrophotometry (Automated), IR Spectrometry, Titrimetry, Total Organic Carbon, Total Organic Halide, Turbidity, Liquid Chromatography/Mass Spectrometer/Mass Spectrometer and Various Radiochemistry Techniques

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste (Liquids and Solids)**
Metals		
Aluminum	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A /6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Antimony	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D
Arsenic	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Barium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Beryllium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Bismuth	EPA 200.8/6020/6020A/6020B	EPA 6020/6020A/6020B
Boron	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Cadmium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Calcium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Chromium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Cobalt	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Copper	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Hafnium	EPA 200.8/6020/6020A/6020B	EPA 6020/6020A/6020B
Iron	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Lead	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Lithium	EPA 200.8/6020/6020A/6020B	EPA 6020/6020A/6020B
Magnesium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Manganese	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Mercury	EPA 1631E/7470/A/245.1/245.2	EPA 7470/7470A/7471A/7471B

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Molybdenum	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Nickel	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Phosphorous	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Potassium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Rhenium	EPA 200.8/6020/6020A/6020B	EPA 6020/6020A/6020B
Rhodium	EPA 6020A/6020B	EPA 6020/6020A/6020B
Selenium	EPA 200.7/200.8/6010B/6010C/6010D/6020 /6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Silicon[1]	EPA 200.7/6010B/6010C/6010D	EPA 6010B/6010C/6010D
Silica as SiO2	EPA 200.7/6010B/6010C/6010D	EPA 6010B/6010C/6010D
Silver	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D
Sodium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Strontium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Sulfur	EPA 200.7/6010B/6010C/6010D	EPA 6010B/6010C/6010D
Tantalum	EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Thallium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Thorium	EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Tin	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D
Titanium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Tungsten	EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Uranium	EPA 200.8/6020/6020A/6020B ASTM D5174-02/97 DOE U-02	EPA 6020/A/B DOE U-02
Isotopic Uranium	EPA 6020A/6020B	EPA 6020A/6020B
Vanadium	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Zinc	EPA 200.7/200.8/6010B/6010C/6010D/6020/ 6020A/6020B	EPA 6010B/6010C/6010D/6020/ 6020A/6020B
Zirconium	EPA 6020A/6020B	EPA 6020A/6020B
General Chemistry		
Acidity	EPA 305.1 SM 2310 B	----------
Adsorbable Organic Halogens (AOX)	EPA 1650	----------
Alkalinity	EPA 310.1 SM 2320B	----------
Ammenable Cyanide	EPA 9012A/9012B/335.1 SM 4500-CN^- G	EPA 9012A/B
Ammonia Nitrogen (and distillation)	EPA 350.1 SM 4500NH_3 B/H	----------
Biochemical Oxygen Demand (BOD)	SM 5210 B	----------

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Bromide	EPA 9056A/300.0	EPA 9056A[3]
Carbon Dioxide (Total and Free by calculation)	SM 4500CO_2 D	----------
Carbonaceous BOD (CBOD)	SM 5210 B	----------
Chemical Oxygen Demand (COD)	EPA 410.4 SM 5220 D	----------
Chloride	EPA 9056A/300.0	EPA 9056A[3]
Chlorine (residual)	EPA 330.5 SM 4500Cl-G	----------
Chromium VI	EPA 7196A SM 3500Cr-B	EPA 7196A
Color	EPA 110.2 SM 2120B	----------
Corrosivity toward Steel	----------	EPA 1110/1110A
Cyanide	EPA 9012A/9012B/335.4 SM4500-CN^-E/G	EPA 9012A/9012B
Density	----------	ASTM D 5057
Extractable Organic Halides (EOX)	----------	EPA 9023
Fluoride	EPA 9056A, EPA 300.0	EPA 9056A[3]
Ignitability	EPA 1020A/B	EPA 1020A/1020B
Iodide	EPA 300.0/9056A	EPA 9056A
Hardness (by calculation/titration)	EPA 130.2/200.7/6010B/C/D/6020A/B SM 2340B/C	EPA 6010B/C/D/6020A/B
Kjeldahl Nitrogen (TKN)	EPA 351.2 SM 4500N_{org} D	----------
MBAS/Surfactants	EPA 425.1 SM 5540C	----------
Nitrate (as N)	EPA 9056A/300.0 SM4500-NO3-F	EPA 9056A[3]
Nitrate-nitrite (as N)	EPA 9056A/300.0	EPA 9056A[3]
Nitrite (as N)	EPA 9056A/300.0	EPA 9056A[3]
Oil & Grease	EPA 1664A	----------
Organic Nitrogen	EPA 351.2/350.1 TKN – Ammonia,	----------
Orthophosphate (as P)	EPA 9056A/300.0	EPA 9056A[3]
Oxygen, Dissolved	SM 4500O G	----------
Paint Filter Liquids Test	----------	EPA 9095B
Perchlorate	EPA 314.0/6850	EPA 6850
pH	EPA 9040B/9040C/9041A/150.1 SM 4500-H^+ B	EPA 9040B/9040C/9045C/ 9045D
Reactive Cyanide	Sec 7.3.3 SW846	Sec 7.3.3 SW846
Reactive Sulfide	Sec 7.3.4 SW846	Sec 7.3.4 SW846
Residue – Filterable (TDS)	EPA 160.1 SM 2540C	----------
Residue - Nonfilterable (TSS)	EPA 160.2 SM 2540D,	----------
Residue - Total	EPA 160.3 SM 2540B	----------
Residue - Total, fixed, and volatile	SM 2540G	----------

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste (Liquids and Solids)**
Residue - Volatile	EPA 160.4 SM 2540E	----------
Salinity	SM 2520B	----------
Specific conductance	EPA 9050A/120.1 SM 2510B	----------
Sulfate	EPA 9056A/300.0	EPA 9056A[3]
Sulfite	SM 4500-SO_3^{2-} B	----------
Sulfide	EPA 9030B/9034/376.2 SM4500 S^{2-}D	EPA 9030B/9034
Total Nitrate-Nitrite	EPA 353.2 SM 4500NO_3^-F	----------
Total Organic Carbon (TOC)	EPA 9060/9060A SM 5310B/415.1	EPA 9060/A[2]
Total Organic Halides (TOX)	EPA 9020B	EPA 9020B[2]
Total Petroleum Hydrocarbons	EPA 1664A	EPA 1664A
Total Phenolics	EPA 9066/420.4	EPA 9066
Total Phosphorous	EPA 365.4 SM 4500P H	----------
Turbidity	EPA 180.1 SM 2130B	----------
Organic Analytes		
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504.1/624/8011/8260B/8260C	EPA 8260B/8260C
1,2 Dibromoethane (EDB)	EPA 504.1/624/8011/8260B/8260C	EPA 8260B/8260C
1,2,3-Trichloropropane	EPA 504.1/624/8011/8260B/8260C	EPA 8260B/8260C
Purgeable Organics (Volatiles)		
1,1,1,2-Tetrachloroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,1,1-Trichloroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,1,2,2-Tetrachloroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,1,2-Trichloro-1,2,2-trifluoroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,1,2-Trichloroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,1-Dichloroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,1-Dichloroethene	EPA 624/8260B/8260C	EPA 8260B/8260C
1,1-Dichloropropene	EPA 624/8260B/8260C	EPA 8260B/8260C
1,2,3-Trichlorobenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
1,2,3-Trichloropropane	EPA 504.1/624/8011/8260B/8260C	EPA 8260B/8260C
1,2,4-Trichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,2,4-Trimethylbenzene	EPA 624/8260B/8260C	EPA 8260B/8060C
1,2-Dichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,2-Dichloroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,2-Dichloropropane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,3,5-Trimethylbenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
1,3-Dichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,3-Dichloropropane	EPA 624/8260B/8260C	EPA 8260B/8260C
1,4-Dichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,4-Dioxane	EPA 522/624/8260B/8260C/625/8270C/ 8270D/	EPA 8260B/8260C/8270C/8270D
1-Chlorohexane	EPA 8260B	EPA 8260B
2,2-Dichloropropane	EPA 624/8260B/8260C	EPA 8260B/8260C

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
2-Butanone (Methyl Ethyl Ketone)	EPA 8015 C/8015D/624/8260B/8260C	EPA 8015C/8015D 8260B/ 8260C
2-Chloroethyl vinyl ether	EPA 624/8260B/8260C	EPA 8260B/8260C
2-Chlorotoluene	EPA 624/8260B/8260C	EPA 8260B/8260C
2-Hexanone	EPA 624/8260B/8260C	EPA 8260B/8260C
2-Nitropropane	EPA 624/8260B/8260C	EPA 8260B/8260C
2-Pentanone	EPA 624/8260B/8260C	EPA 8260B/8260C
4-Chlorotoluene	EPA 624/8260B/8260C	EPA 8260B/8260C
4-Isopropyltoluene	EPA 624/8260B/8260C	EPA 8260B/8260C
4-Methyl-2-pentanone	EPA 624/8260B/8260C	EPA 8260B/8260C
Acetone	EPA 624/8260B/8260C	EPA 8260B/8260C
Acetonitrile	EPA 624/8260B/8260C	EPA 8260B/8260C
Acrolein (Propenal)	EPA 624/8260B/8260C	EPA 8260B/8260C
Acrylonitrile	EPA 624/8260B/8260C	EPA 8260B/8260C
Allyl Chloride	EPA 624/8260B/8260C	EPA 8260B/8260C
Benzene	EPA 624/8260B/8260C	EPA 8260B/8260C
Benzyl chloride	EPA 624/8260B/8260C	EPA 8260B/8260C
Bromobenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
Bromochloromethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Bromodichloromethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Bromoform	EPA 624/8260B/8260C	EPA 8260B/8260C
Bromomethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Carbon disulfide	EPA 624/8260B/8260C	EPA 8260B/8260C
Carbon tetrachloride	EPA 624/8260B/8260C	EPA 8260B/8260C
Chlorobenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
Chloroethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Chloroform	EPA 624/8260B/8260C	EPA 8260B/8260C
Chloromethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Chloroprene	EPA 624/8260B/8260C	EPA 8260B/8260C
cis-1,2-Dichloroethene	EPA 624/8260B/8260C	EPA 8260B/8260C
cis-1,3-Dichloropropene	EPA 624/8260B/8260C	EPA 8260B/8260C
cis-1,4-Dichloro-2-butene	EPA 624/8260B/8260C	EPA 8260B/8260C
Cyclohexane	EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexanone	EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexene	EPA 8260B	EPA 8260B
Dibromochloromethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Dibromomethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Dichlorodifluoromethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Diethyl ether	EPA 624/8260B/8260C	EPA 8260B/8260C
Ethyl Acetate	EPA 624/8015C/8015D/8260B/8260C	EPA 8015C/8015D/8260B/8260C
Ethyl Benzene	EPA 624/8260B/8260C	EPA 8260B/8260C
Ethyl methacrylate	EPA 624/8260B/8260C	EPA 8260B/8260C
Ethyl tert butyl ether	EPA 8260B	EPA 8260B
Hexachlorobutadiene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
Iodomethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Isobutyl Alcohol	EPA 624/8015B/8015C/8260B/8260C	EPA 8260B/C
Isopropyl Alcohol	EPA 8260B	EPA 8260B
Isopropylbenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
Isopropyl Ether	EPA 8260B	EPA 8260B
m+p-Xylene	EPA 624/8260B/8260C	EPA 8260B/8260C

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste (Liquids and Solids)**
Methacrylonitrile	EPA 624/8260B/8260C	EPA 8260B/8260C
Methyl Acetate	EPA 8260B/8260C	EPA 8260B/C
Methyl methacrylate	EPA 624/8260B/8260C	EPA 8260B/8260C
Methyl tert amyl ether (TAME)	EPA 8260B	EPA 8260B
Methyl tert butyl ether (MTBE)	EPA 624/8260B/8260C	EPA 8260B/8260C
Methylcyclohexane	EPA 8260B/8260C	EPA 8260B/C
Methylene chloride	EPA 624/8260B/8260C	EPA 8260C
Naphthalene	EPA 624/8260B/8260C/625/8270C/8270D[4] /8310	EPA 8260B/8260C/8270C/8270D[4] /8310
n-Butyl alcohol	EPA 624/8015C/8015D/8260B/8260C	EPA 8015C/8015D/8260B/8260C
n-Butylbenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
n-Propylbenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
o-Xylene	EPA 624/8260B/8260C	EPA 8260B/8260C
Pentachloroethane	EPA 624/8260B/8260C/8270C/8270D	EPA 8260B/8260C/8270C/8270D
Propionitrile	EPA 624/8260B/8260C	EPA 8260B/8260C
Sec-Butylbenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
Styrene	EPA 624/8260B/8260C	EPA 8260B/8260C
tert-Butyl Alcohol	EPA 8260B/8260C	EPA 8260B/8260C
tert-Butylbenzene	EPA 624/8260B/8260C	EPA 8260B/8260C
Tetrachloroethene	EPA 624/8260B/8260C	EPA 8260B/8260C
Toluene	EPA 624/8260B/8260C	EPA 8260B/8260C
trans-1,2-Dichloroethene	EPA 624/8260B/8260C	EPA 8260B/8260C
trans-1,3-Dichloropropene	EPA 624/8260B/8260C	EPA 8260B/8260C
trans-1,4-Dichloro-2-butene	EPA 624/8260B/8260C	EPA 8260B/8260C
Trichloroethene	EPA 624/8260B/8260C	EPA 8260B/8260C
Trichlorofluoromethane	EPA 624/8260B/8260C	EPA 8260B/8260C
Trihalomethanes	EPA 624/8260B/8260C	EPA 8260B/8260C
Vinyl acetate	EPA 624/8260B/8260C	EPA 8260B/8260C
Vinyl chloride	EPA 624/8260B/8260C	EPA 8260B/8260C
Xylenes, total	EPA 624/8260B/8260C	EPA 8260B/8260C
Semivolatile Compounds		
1,2,4,5-Tetrachlorobenzene	EPA 625/8270C/8270D	EPA 8270C/8270D
1,2,4-Trichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,2-Dichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,2-Diphenylhydrazine	EPA 625/8270C/8270D	EPA 8270C/8270D
1,3,5-Trinitrobenzene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
1,3-Dichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,3-Dinitrobenzene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
1,4-Dichlorobenzene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
1,4-Dioxane	EPA 624/8260B/8260C/625/8270C/8270D/ 522	EPA 8260B/8260C/8270C/8270D
1,4-Dinitrobenzene	EPA 625/8270C/8270D	EPA 8270C/8270D
1,4-Naphthoquinone	EPA 625/8270C/8270D	EPA 8270C/8270D
1,4-Phenylenediamine	EPA 625/8270C/8270D	EPA 8270C/8270D
1-Methylnaphthalene	EPA 625/8270C/8270D[4]	EPA 8270C/8270D[4]
1-Naphthylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
2,2-Dichlorobenzil	EPA 625/8270C/8270D	EPA 8270C/8270D
2,3,4,6-Tetrachlorophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2,3-Dichloroaniline	EPA 625/8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
2,4,5-Trichlorophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2,4,6-Trichlorophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2,4-Dichlorophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2,4-Dimethylphenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2,4-Dinitrophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2,4-Dinitrotoluene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
2,6-Dichlorophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2,6-Dinitrotoluene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
2-Acetylaminofluorene	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Butoxyethanol	EPA 8270C/8270D	EPA 8270C/8070D
2-Chloronaphthalene	EPA 625/8270C/8270D[4]	EPA 8270C/8270D[4]
2-Chlorophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Ethoxyethanol	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Methyl-4,6-Dinitrophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Methylnaphthalene	EPA 625/8270C/8270D[4]	EPA 8270C/8270D
2-Methylphenol (o-cresol)	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Naphthylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Nitroaniline	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Nitrophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
2-Picoline (2-Methylpyridine)	EPA 625/8270C/8270D	EPA 8270C/8270D
3,3'-Dichlorobenzidine	EPA 625/8270C/8270D[4]	EPA 8270C/8270D
3,3'-Dimethylbenzidine	EPA 625/8270C/8270D	EPA 8270C/8270D
3/4-Methylphenols(m/p cresols)	EPA 625/8270C/8270D	EPA 8270C/8270D
3-Methylcholanthrene	EPA 625/8270C/8270D	EPA 8270C/8270D
3-Nitroaniline	EPA 625/8270C/8270D	EPA 8270C/8270D
4,4-Dichlorodiphenyl sulfone	EPA 8270C/8270D	EPA 8270C/8270D
4-Aminobiphenyl	EPA 625/8270C/8270D	EPA 8270C/8270D
4-Bromophenyl phenyl ether	EPA 625/8270C/8270D	EPA 8270C/8270D
4-Chloro-3-methylphenol	EPA 625/8270C/8270D	EPA 8270C/8270D
4-Chloroaniline	EPA 625/8270C/8270D	EPA 8270C/8270D
4-Chlorophenyl phenyl ether	EPA 625/8270C/8270D	EPA 8270C/8270D
4-Chlorothioanisole	EPA 8270C/8270D	EPA 8270C/8070D
4-Chlorothiophenol	EPA 8270C/8270D	EPA 8270C/8270D
4-Nitroaniline	EPA 625/8270C/8270D	EPA 8270C/8270D
4-Nitrophenol	EPA 625/8270C/8270D	EPA 8270C/8270D
5-Nitro-o-toluidine	EPA 625/8270C/8270D	EPA 8270C/8270D
7,12-Dimethylbenz(a)anthracene	EPA 625/8270C/8270D	EPA 8270C/8270D
Acenaphthene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Acenaphthylene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Acetophenone	EPA 625/8270C/8270D	EPA 8270C/8270D
alpha-,alpha-Dimethylphenethylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
alpha-Terpineol	EPA 625/8270C/8270D	EPA 8270C/8270D
Aniline	EPA 625/8270C/8270D	EPA 8270C/8270D
Anthracene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Aramite	EPA 625/8270C/8270D	EPA 8270C/8270D
Atrazine	EPA 625/8270C/8270D	EPA 8270C/8270D
Benzaldehyde	EPA 625/8270C/8270D	EPA 8270C/8270D
Benzidine	EPA 625/8270C/8270D	EPA 8270C/8270D
Benzo (a) anthracene	EPA 625, 8270C/D[4], 8310	EPA 8270C/8270D[4]/8310
Benzo (a) pyrene	EPA 625, 8270C/D[4], 8310	EPA 8270C/8270D[4]/8310

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Benzo (b) fluoranthene	EPA 625, 8270C/D[4], 8310	EPA 8270C/8270D[4]/8310
Benzo (ghi) perylene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Benzo (k) fluoranthene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Benzoic acid	EPA 625/8270C/8270D	EPA 8270C/8270D
Benzyl alcohol	EPA 625/8270C/8270D	EPA 8270C/8270D
Biphenyl	EPA 625/8270C/8270D	EPA 8270C/8270D
Bis (2-chloroethoxy) methane	EPA 625/8270C/8270D	EPA 8270C/8270D
Bis (2-chloroethyl) ether	EPA 625/8270C/8270D	EPA 8270C/8270D
Bis (2-chloro-1 methyl-ethyl) ether	EPA 625/8270C/8270D	EPA 8270C/8270D
Bis (2-ethylhexyl) phthalate	EPA 625/8270C/8270D	EPA 8270C/8270D
Bis(chloromethyl) ether	EPA 8270C/8270D	EPA 8270C/8270D
Bis(p-chlorophenyl) disulfide	EPA 8270C/8270D	EPA 8270C/8270D
Bis(p-chlorophenyl) sulfone	EPA 8270C/8270D	EPA 8270C/8270D
Butyl benzyl phthalate	EPA 625/8270C/8270D	EPA 8270C/8270D
Caprolactam	EPA 625/8270C/8270D	EPA 8270C/8270D
Carbazole	EPA 625/8270C/8270D	EPA 8270C/8270D
Chlorobenzilate	EPA 625/8270C/8270D	EPA 8270C/8270D
Chrysene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
cis-Diallate	EPA 625/8270C/8270D	EPA 8270C/8270D
Diallate	EPA 625/8270C/8270D	EPA 8270C/8270D
Dibenzo (a,e) pyrene	EPA 625/8270C/8270D	EPA 8270C/8270D
Dibenzo (a,h) anthracene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Dibenzofuran	EPA 625/8270C/8270D	EPA 8270C/8270D
Diethyl phthalate	EPA 625/8270C/8270D	EPA 8270C/8270D
Dimethoate	EPA 625/8270C/8270D	EPA 8270C/8270D
Dimethyl phthalate	EPA 625/8270C/8270D	EPA 8270C/8270D
Di-n-butyl phthalate	EPA 625/8270C/8270D	EPA 8270C/8270D
Di-n-octyl phthalate	EPA 625/8270C/8270D	EPA 8270C/8270D
Dinoseb	EPA 625/8270C/8270D	EPA 8270C/8270D
Diphenyl Disulfide	EPA 8270C/8270D	EPA 8270C/8270D
Diphenyl sulfide	EPA 8270C/8270D	EPA 8270C/8270D
Diphenyl sulfone	EPA 8270C/8270D	EPA 8270C/8270D
Diphenylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
Disulfoton	EPA 625/8270C/8270D	EPA 8270C/8270D
Ethyl methacrylate	EPA 625/8270C/8270D	EPA 8270C/8270D
Ethyl methanesulfonate	EPA 625/8270C/8270D	EPA 8270C/8270D
Famphur	EPA 625/8270C/8270D	EPA 8270C/8270D
Fluoranthene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Fluorene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Hexachlorobenzene	EPA 625/8270C/8270D	EPA 8270C/8270D
Hexachlorobutadiene	EPA 624/8260B/8260C/625/8270C/8270D	EPA 8260B/8260C/8270C/8270D
Hexachlorocyclopentadiene	EPA 625/8270C/8270D	EPA 8270C/8270D
Hexachloroethane	EPA 625/8270C/8270D	EPA 8270C/8270D
Hexachlorophene	EPA 625/8270C/8270D	EPA 8270C/8270D
Hexachloropropene	EPA 625/8270C/8270D	EPA 8270C/8270D
Hydroxymethyl phthalimide	EPA 625/8270C/8270D	EPA 8270C/8270D
Indeno (1,2,3-cd) pyrene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Isodrin	EPA 625/8270C/8270D	EPA 8270C/8270D
Isophorone	EPA 625/8270C/8270D	EPA 8270C/8270D
Isosafrole	EPA 625/8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste (Liquids and Solids)**
Kepone	EPA 625/8270C/8270D	EPA 8270C/8270D
Methapyrilene	EPA 625/8270C/8270D	EPA 8270C/8270D
Methyl methacrylate	EPA 8270C/8270D	EPA 8270C/8270D
Methyl methanesulfonate	EPA 625/8270C/8270D	EPA 8270C/8270D
Methyl parathion	EPA 625/8270C/8270D	EPA 8270C/8270D
Methylene bis(2-chloroaniline)	EPA 625/8270C/8270D	EPA 8270C/8270D
m-Toluidine	EPA 625/8270C/8270D	EPA 8270C/8270D
Naphthalene	EPA 624, 8260B/C, 625, 8270C/D[4], 8310	EPA8260B/8260C/8270C/8270D[4]/ 8310
n-Decane	EPA 625/8270C/8270D	EPA 8270C/8270D
Nitrobenzene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
Nitroquinoline-1-oxide	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosodietheylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosodimethylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosodimethylethylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosodi-n-butylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosodi-n-propylamine	EPA 625/8270C/8270D[4]	EPA 8270C/8270D
N-Nitrosodiphenylamine	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosomorpholine	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosopiperidine	EPA 625/8270C/8270D	EPA 8270C/8270D
N-Nitrosopyrrolidine	EPA 625/8270C/8270D[4]	EPA 8270C/8270D
n-Octadecane	EPA 625/8270C/8270D	EPA 8270C/8270D
o,o,o-Triethyl phosphorothioate	EPA 625/8270C/8270D	EPA 8270C/8270D
Octachlorostyrene	EPA 8270C/8270D	EPA 8270C/8270D
o-Toluidine	EPA 625/8270C/8270D	EPA 8270C/8270D
Parathion, ethyl	EPA 625/8270C/8270D	EPA 8270C/8270D
p-Benzoquinone	EPA 625/8270C/8270D	EPA 8270C/8270D
p-Dimethylaminoazobenzene	EPA 625/8270C/8270D	EPA 8270C/8270D
Pentachlorobenzene	EPA 625/8270C/8270D	EPA 8270C/8270D
Pentachloroethane	EPA 625/624/8260B/8260C/8270C/8270D	EPA 8260B/8260C/8270C/8270D
Pentachloronitrobenzene	EPA 625/8270C/8270D	EPA 8270C/8270D
Pentachlorophenol	EPA 625/8270C/8270D/8151A	EPA 8270C/8270D/8151A
Phenacetin	EPA 625/8270C/8270D	EPA 8270C/8270D
Phenanthrene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Phenol	EPA 625/8270C/8270D	EPA 8270C/8270D
Phorate	EPA 625/8270C/8270D	EPA 8270C/8270D
Pronamide (Kerb)	EPA 625/8270C/8270D	EPA 8270C/8270D
p-Toluidine	EPA 625/8270C/8270D	EPA 8270C/8270D
Pyrene	EPA 625/8270C/8270D[4]/8310	EPA 8270C/8270D[4]/8310
Pyridine	EPA 625/8270C/8270D	EPA 8270C/8270D
Safrole	EPA 625/8270C/8270D	EPA 8270C/8270D
Sulfotepp	EPA 625/8270C/8270D	EPA 8270C/8270D
Thionazin (Zinophos)	EPA 625/8270C/8270D	EPA 8270C/8270D
Thiophenol (Benzenethiol)	EPA 8270C/8270D	EPA 8270C/8270D
trans-Diallate	EPA 625/8270C/8270D	EPA 8270C/8270D
Tributyl Phosphate	EPA 625/8270C/8270D	EPA 8270C/8270D
Pesticides & PCBs		
2,4'-DDD	EPA 8081A/8081B	EPA 8081A/8081B
2,4'-DDE	EPA 8081A/8081B	EPA 8081A/8081B

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
2,4'-DDT	EPA 8081A/8081B	EPA 8081A/8081B
4,4'-DDT	EPA 608/8081A/8081B	EPA 8081A/8081B
4,4'-DDD	EPA 608/8081A/8081B	EPA 8081A/8081B
4,4'-DDE	EPA 608/8081A/8081B	EPA 8081A/8081B
Aldrin	EPA 608/8081A/8081B	EPA 8081A/8081B
alpha-BHC	EPA 608/8081A/8081B	EPA 8081A/8081B
beta-BHC	EPA 608/8081A/8081B	EPA 8081A/8081B
Chlordane (N.O.S)	EPA 608/8081A/8081B	EPA 8081A/8081B
cis-Chlordane (alpha-Chlordane)	EPA 608/8081A/8081B	EPA 8081A/8081B
cis-Nonachlor	EPA 8081A/8081B	EPA 8081A/8081B
delta-BHC	EPA 608/8081A/8081B	EPA 8081A/8081B
Dieldrin	EPA 608/8081A/8081B	EPA 8081A/8081B
Endonsulfan sulfate	EPA 608/8081A/8081B	EPA 8081A/8081B
Endosulfan I	EPA 608/8081A/8081B	EPA 8081A/8081B
Endosulfan II	EPA 608/8081A/8081B	EPA 8081A/8081B
Endrin	EPA 608/8081A/8081B	EPA 8081A/8081B
Endrin aldehyde	EPA 608/8081A/8081B	EPA 8081A/8081B
Endrin ketone	EPA 608/8081A/8081B	EPA 8081A/8081B
gamma-BHC	EPA 608/8081A/8081B	EPA 8081A/8081B
Heptachlor	EPA 608/8081A/8081B	EPA 8081A/8081B
Heptachlor epoxide	EPA 608/8081A/8081B	EPA 8081A/8081B
Hexachlorobenzene	EPA 8081A/8081B	EPA 8081A/8081B
Methoxychlor	EPA 608/8081A/8081B	EPA 8081A/8081B
Mirex	EPA 8081A/8081B	EPA 8081A/8081B
Oxychlordane	EPA 8081A/8081B	EPA 8081A/8081B
Toxaphene	EPA 608/8081A/8081B	EPA 8081A/8081B
trans-Chlordane	EPA 608/8081A/8081B	EPA 8081A/8081B
trans-Nonachlor	EPA 8081A/8081B	EPA 8081A/8081B
PCB-1016 (Aroclor)	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1221	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1232	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1242	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1248	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1254	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1260	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1262	EPA 608/8082/8082A	EPA 8082/8082A
PCB-1268	EPA 608/8082/8082A	EPA 8082/8082A
Total Aroclors	EPA 608/8082/8082A	EPA 8082/8082A
FID Compounds		
1,1,1-Trichloroethane	EPA 8015C/8015D	EPA 8015C/8015D
2-Butanone (Methyl Ethyl Ketone)	EPA 624/8015C/8015D/8260B/8260C	EPA 8015C/8015D/8260B/8260C
4-Methyl-2-Pentanone	EPA 8015C/8015D	EPA 8015C/8015D
Acetone	EPA 8015C/8015D	EPA 8015C/8015D
Benzene	EPA 8015C/8015D	EPA 8015C/8015D
Chloroform	EPA 8015C/8015D	EPA 8015C/8015D
Diesel Range Organics (DRO)	EPA 8015C/8015D	EPA 8015C/8015D
Diethylene Glycol	EPA 8015C/8015D	EPA 8015C/8015D
Ethanol	EPA 8015C/8015D	EPA 8015C/8015D
Ethyl acetate	EPA 624/8015C/8015D/8260B/8260C	EPA 8015C/8015D/8260B/8260C

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Ethylbenzene	EPA 8015C/8015D	EPA 8015C/8015D
Ethylene Glycol	EPA 8015C/8015D	EPA 8015C/8015D
Gas Range Organics (GRO)	EPA 8015C/8015D	EPA 8015C/8015D
Kerosene	EPA 8015C/8015D	EPA 8015C/8015D
Isobutyl Alcohol	EPA 624/8015C/8015D/8260B/8260C	EPA 8015C/8015D/8260B/8260C
Isopropyl Alcohol (2-Propanol)	EPA 8015C/8015D	EPA 8015C/8015D
m, p-Xylenes	EPA 8015C/8015D	EPA 8015C/8015D
Methanol	EPA 8015C/8015D	EPA 8015C/8015D
Methylene Chloride	EPA 8015C/8015D	EPA 8015C/8015D
n-Butyl alcohol	EPA 624/8015C/8015D/8260B/8260C	EPA 8015C/8015D/8260B/8260C
o-Xylene	EPA 8015C/8015D	EPA 8015C/8015D
Propylene Glycol	EPA 8015C/8015D	EPA 8015C/8015D
Toluene	EPA 8015C/8015D	EPA 8015C/8015D
Triethylene Glycol	EPA 8015C/8015D	EPA 8015C/8015D
Volatile Petroleum Products	NWTPH-Gx(WDOE)	NWTPH-Gx(WDOE)
Semi-Volatile Petroleum Products	NWTPH-Dx(WDOE)	NWTPH-Dx(WDOE)
C8-C10 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C10-C12 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C12-C16 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C16-C21 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C21-C34 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
Alaska GRO	AK-101 (GRO)	AK-101 (GRO)
Alaska DRO	AK-102 (DRO)	AK-102 (DRO)
Alaska RRO	AK-103 (RRO)	AK-103 (RRO)
EPH Aliphatic C9 – C18	MADEP EPH	MADEP EPH
EPH Aliphatic C19 – C36	MADEP EPH	MADEP EPH
EPH Aromatic C11 - C22 Unadjusted	MADEP EPH	MADEP EPH
Nitrosamines, Nitroaromatics	**8330A is by either LC/MS/MS or HPLC 8330B is by LC/MS/MS**	
1,3,5-Trinitrobenzene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
1,3-Dinitrobenzene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
2,4,6-Trinitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
2,4-Dinitrotoluene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
2,6-Dinitrotoluene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
2-Amino-4,6-Dinitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
2-Nitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Nitrosamines, Nitroaromatics	**8330B is by LC/MS/MS. 8330A is by either LC/MS/MS or HPLC**	
3,5-Dinitroaniline	EPA 8330B[5]	EPA 8330B[5]
3-Nitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
4-Amino-2,6-Dinitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
4-Nitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Nitrobenzene	EPA 625/8270C/8270D/8330A/8330B[5]	EPA 8270C/8270D/8330A/8330B[5]
Nitroglycerin	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Pentaerythritoltetranitrate (PETN)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Dissolved Gases by FID		
Ethane	RSK 175	
Ethene	RSK 175	
Methane	RSK 175	
Herbicides		
2,4-D	EPA 8151A	EPA 8151A
2,4-DB	EPA 8151A	EPA 8151A
Dalapon	EPA 8151A	EPA 8151A
Dicamba	EPA 8151A	EPA 8151A
Dichloroprop	EPA 8151A	EPA 8151A
Dinoseb	EPA 625/8151A/8270C/8270D	EPA 8151A/8270C/8270D
MCPA	EPA 8151A	EPA 8151A
MCPP	EPA 8151A	EPA 8151A
2,4,5-T	EPA 8151A	EPA 8151A
2,4,5-TP (Silvex)	EPA 8151A	EPA 8151A
Pentachlorophenol	EPA 8151A	EPA 8151A
Radiochemistry		
Barium 133	DOE 4.5.2.3	DOE 4.5.2.3
Cesium 134	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Cesium 137	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Cobalt-60	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Gamma Emitters	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Gross Alpha	EPA 900.0/9310	EPA 9310
Gross Beta	EPA 900.0/9310	EPA 9310
Radioactive Iodine	EPA 901.1/902.0 DOE 4.5.2.3	DOE 4.5.2.3
Radium-226	EPA 903.0/903.1 DOE Ra-04	DOE Ra-04
Radium-228	EPA 904.0/9320 DOE 4.5.2.3	EPA9320 DOE 4.5.2.3
Total Alpha Radium	EPA 903.0/9315	EPA 9315
Radon-222	SM 7500 Rn-B	----------
Strontium-89	EPA 905.0 DOE Sr-01	DOE Sr-01
Strontium-90	EPA 905.0 DOE Sr-02	DOE Sr-02
Thorium	EMSL-LV	EMSL-LV
Tritium	EPA 906.0	EPA 906.0 Modified
Uranium	EPA 200.8/6020/6020A ASTM D5174-02/97 DOE U-02	EPA 6020/6020A DOE U-02
Zinc-65	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Preparatory and Clean-up Methods		
Toxicity Characteristic Leaching Procedure (Inorganics, Extractable Organics, Volatile Organics)	EPA 1311	EPA 1311
Synthetic Precipitation Leaching Procedure	EPA 1312	EPA 1312
Waste Extraction Test (W.E.T.)	CCR Ch. 11, Article 5, Appendix II	CCR Ch. 11, Article 5, Appendix II
Anion Preparation	EPA 9056A[3]	EPA 9056A[3]
Cyanide Distillation	EPA 9010B/9010C SM 4500CN^- C	EPA 9010B/9010C[3]
Sulfide Distillation	EPA 9030B	EPA 9030B
Metals Digestion	EPA 200.2/3005A/3010A	EPA 3050B
Alkaline Digestion for Hex Chromium	----------	EPA 3060A
Bomb Preparation for Solid Waste	----------	EPA 5050
Mercury Preparation	EPA 245.1/245.2/7470/7470A	EPA 7471A/7471B
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	----------
Solid Phase Extraction	EPA 3535A	EPA 3535A
Automated Soxhlet Extraction	----------	EPA 3541
Ultrasonic Extraction	----------	EPA 3550C
Waste Dilution	----------	EPA 3580A
Waste Dilution for Volatile Organics	----------	EPA 3585
Purge and Trap for Volatile Organics	EPA 5030A/5030B/5030C	EPA 5035/5035A/5035H/5035L
Alumina Clean-up	----------	EPA 3610B/3611B
Florisil Clean-up	----------	EPA 3620B/3620C
Silica Gel Clean-up	----------	EPA 3630C
Gel Permeation Clean-up	----------	EPA 3640A
Sulfur Clean-up	EPA 3660B	EPA 3660B
Sulfuric Acid/Permanganate Clean-up	EPA 3665A	EPA 3665A

Metals on Filters	Air Filters
Aluminum	EPA 6010B/6010C/6010D NIOSH 7303
Antimony	EPA 6010B/6010C/6010D NIOSH 7303
Arsenic	EPA 6010B/6010C/6010D NIOSH 7303
Barium	EPA 6010B/6010C/6010D NIOSH 7303
Beryllium	EPA 6010B/6010C/6010D NIOSH 7303
Cadmium	EPA 6010B/6010C/6010D NIOSH 7303
Calcium	EPA 6010B/6010C/6010D NIOSH 7303
Chromium	EPA 6010B/6010C/6010D NIOSH 7303
Cobalt	EPA 6010B/6010C/6010D NIOSH 7303
Copper	EPA 6010B/6010C/6010D

Metals on Filters	Air Filters
	NIOSH 7303
Iron	EPA 6010B/6010C/6010D NIOSH 7303
Lead	EPA 6010B/6010C/6010D NIOSH 7303
Magnesium	EPA 6010B/6010C/6010D NIOSH 7303
Manganese	EPA 6010B/6010C/6010D NIOSH 7303
Molybdenum	EPA 6010B/6010C/6010D NIOSH 7303
Nickel	EPA 6010B/6010C/6010D NIOSH 7303
Phosphorous	EPA 6010B/6010C/6010D NIOSH 7303
Potassium	EPA 6010B/6010C/6010D NIOSH 7303
Selenium	EPA 6010B/6010C/6010D NIOSH 7303
Silver	EPA 6010B/6010C/6010D NIOSH 7303
Sodium	EPA 6010B/6010C/6010D NIOSH 7303
Strontium	EPA 6010B/6010C/6010D NIOSH 7303
Sulfur	EPA 6010B/6010C/6010D NIOSH 7303
Tin	EPA 6010B/6010C/6010D NIOSH 7303
Titanium	EPA 6010B/6010C/6010D NIOSH 7303
Uranium	EPA 6010B/6010C/6010D NIOSH 7303
Vanadium	EPA 6010B/6010C/6010D NIOSH 7303
Zinc	EPA 6010B/6010C/6010D NIOSH 7303

Drinking Water Organics	Drinking Water
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504.1/524.2
1,2 Dibromoethane (EDB)	EPA 504.1/524.2
1,2,3-Trichloropropane	EPA 504.1
1,4-Dioxane	EPA 522
1,1,1,2-Tetrachloroethane	EPA 524.2
1,1,1-Trichloroethane	EPA 524.2
1,1,2,2-Tetrachloroethane	EPA 524.2
1,1,2-Trichloroethane	EPA 524.2
1,1-Dichloroethane	EPA 524.2
1,1-Dichloroethene	EPA 524.2
1,1-Dichloropropene	EPA 524.2
1,2,3-Trichlorobenzene	EPA 524.2
1,2,3-Trichloropropane	EPA 524.2
1,2,4-Trichlorobenzene	EPA 524.2

Drinking Water Organics	Drinking Water
1,2,4-Trimethylbenzene	EPA 524.2
1,2-Dichlorobenzene	EPA 524.2
1,2-Dichloroethane	EPA 524.2
1,2-Dichloropropane	EPA 524.2
1,3,5-Trimethylbenzene	EPA 524.2
1,3-Dichlorobenzene	EPA 524.2
1,3-Dichloropropane	EPA 524.2
1,4-Dichlorobenzene	EPA 524.2
2,2-Dichloropropane	EPA 524.2
2-Butanone (Methyl Ethyl Ketone)	EPA 524.2
2-Chlorotoluene	EPA 524.2
2-Hexanone	EPA 524.2
4-Chlorotoluene	EPA 524.2
4-Isopropyltoluene	EPA 524.2
4-Methyl-2-pentanone	EPA 524.2
Acetone	EPA 524.2
Benzene	EPA 524.2
Bromobenzene	EPA 524.2
Bromochloromethane	EPA 524.2
Bromodichloromethane	EPA 524.2
Bromoform	EPA 524.2
Bromomethane	EPA 524.2
Carbon disulfide	EPA 524.2
Carbon tetrachloride	EPA 524.2
Chlorobenzene	EPA 524.2
Chloroethane	EPA 524.2
Chloroform	EPA 524.2
Chloromethane	EPA 524.2
cis-1,2-Dichloroethene	EPA 524.2
cis-1,3-Dichloropropene	EPA 524.2
Dibromochloromethane	EPA 524.2
Dibromomethane	EPA 524.2
Dichlorodifluoromethane	EPA 524.2
Ethyl Benzene	EPA 524.2
Hexachlorobutadiene	EPA 524.2
Iodomethane	EPA 524.2
Isopropylbenzene	EPA 524.2
Methyl tert butyl ether (MTBE)	EPA 524.2
Methylene chloride	EPA 524.2
m+p-Xylene	EPA 524.2
Naphthalene	EPA 524.2
n-Butylbenzene	EPA 524.2
n-Propylbenzene	EPA 524.2
o-Xylene	EPA 524.2
Sec-Butylbenzene	EPA 524.2
Styrene	EPA 524.2
Tert-Butylbenzene	EPA 524.2
Tetrachloroethene	EPA 524.2
Toluene	EPA 524.2
trans-1,2-Dichloroethene	EPA 524.2
trans-1,3-Dichloropropene	EPA 524.2
Trichloroethene	EPA 524.2

Drinking Water Organics	Drinking Water
Trichlorofluoromethane	EPA 524.2
Trihalomethanes	EPA 524.2
Vinyl chloride	EPA 524.2
Xylenes, total	EPA 524.2
Bromoacetic Acid	EPA 552.2
Bromochloroacetic acid	EPA 552.2
Chloroacetic acid	EPA 552.2
Dibromoacetic acid	EPA 552.2
Dichloroacetic acid	EPA 552.2
Trichloroacetic acid	EPA 552.2

1 - Calculated from silica determination

2 – Applicable only to liquid 'Solid Hazardous Waste', where liquids may include aqueous, non-aqueous, and oily wastes. Solids may include soils, sediments, sludges, tissues, filters and any matrix deemed non-liquid.

3 – The referenced method is modified to include a simple prep for non-aqueous and/or solid matrix samples.

4 – The analytes may be determined by Selective Ion Monitoring (SIM) using either 8270C or 8270D.

5 – 8330B analysis is performed on LC/MS/MS. 8330A may be performed on either LC/MS/MS or HPLC.

Accreditation is also granted to this laboratory to perform the following tests on children's toys:

CHEMICAL

Lead in Paint by ICP	16 CFR part 1303 (using GL-MA-E-009 and GL-MA-E-013)

Additionally, in recognition of the successful completion of the A2LA evaluation process (including an assessment of the laboratory's compliance with the 2009 TNI Standard Requirements), accreditation is granted to this laboratory to perform the following bioassay analyses on bone, tissue, urine, fecal, and nasal swabs.

	Preparation SOP	**Analytical SOP**
Bioassay Analysis		
Alpha Spectrometry: Alpha: Am-241, Cm-242, Cm-243/244, Cm 245/246, Cf-252, Np-237, Po-208, Po-209, Po-210, Pu-236, Pu-238, Pu-239/240, Pu-242, Pu-244, Ra-224, Ra-226, Th-228, Th-229, Th-230, Th-232, U-232, U-233/234, U-235/236, U-238	GL-RAD-B-001, GL-RAD-B-002, GL-RAD-B-003, GL-RAD-B-010, GL-RAD-B-012, GL-RAD-B-013, GL-RAD-B-017, GL-RAD-B-038, GL-RAD-B-040, GL-RAD-B-041	GL-RAD-B-009
	Preparation SOP	**Analytical SOP**
Bioassay Analysis		
Liquid Scintillation Spectrometry: C-14, Fe-55, Gross Alpha, H-3, Ni-59, Ni-63, Pu-241, Tc-99	GL-RAD-B-001, GL-RAD-B-008, GL-RAD-B-011, GL-RAD-B-012, GL-RAD-B-013, GL-RAD-B-016, GL-RAD-B-020, GL-RAD-B-023	GL-RAD-I-004, GL-RAD-I-014, GL-RAD-I-017
Gas Flow Proportional Counting: Beta: Sr-90	GL-RAD-B-001	GL-RAD-I-006, GL-RAD-I-015, GL-RAD-I-016
Gross Alpha/Gross Beta	GL-RAD-B-022	GL-RAD-I-006
Kinetic Phosphorescence Analyzer: Total Uranium	GL-RAD-B-019	GL-RAD-B-018
Radon Emanation: Ra-226	GL-RAD-B-002	GL-RAD-I-007
Refractometer: Specific Gravity	GL-RAD-B-027	GL-RAD-B-027
ICP-MS: Uranium Isotopes	GL-RAD-B-035	GL-RAD-B-034
Gamma Spectrometry: Gamma: Ni-59, 46 to 1836 keV	GL-RAD-B-020, GL-RAD-A-013	GL-RAD-I-001

Accredited Laboratory

A2LA has accredited

GEL LABORATORIES, LLC

Charleston, SC

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.0 of the DoD Quality System Manual for Environmental Laboratories (QSM), accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Presented this 7th day of July 2015.

President and CEO
For the Accreditation Council
Certificate Number 2567.01
Valid to June 30, 2017
Revised November 9, 2016

For the tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

Field of Testing 106: Radiochemistry of Drinking Water

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Sample Preparation
106.010	001	EPA 900.0	Gross Alpha		
106.010	002	EPA 900.0	Gross Beta		
106.020	001	EPA 901.0	Radioactive Cesium		
106.030	001	EPA 901.1	Radioactive Cesium		
106.030	002	EPA 901.1	Radioactive Iodine		
106.030	003	EPA 901.1	Gamma Emitters		
106.040	001	EPA 902.0	Radioactive Iodine		
106.050	001	EPA 903.0	Total Alpha Radium		
106.050	002	EPA 903.0	Radium-226		
106.051	001	EPA 903.1	Radium-226		
106.060	001	EPA 904.0	Radium-228		
106.070	001	EPA 905.0	Strontium-89, 90		
106.070	002	EPA 905.0	Strontium-89		
106.070	003	EPA 905.0	Strontium-90		
106.080	001	EPA 906.0	Tritium		
106.090	001	EPA 908.0	Uranium		
106.091	001	EPA 908.1	Uranium		
106.092	001	EPA 200.8	Uranium		
106.100	001	EPA 600/4-75-008, p1	Gross Alpha		
106.100	002	EPA 600/4-75-008, p1	Gross Beta		
106.100	003	EPA 600/4-75-008, p4	Radioactive Cesium		
106.100	004	EPA 600/4-75-008, p6	Radioactive Iodine		
106.100	005	EPA 600/4-75-008, p13	Total Alpha Radium		
106.100	007	EPA 600/4-75-008, p16	Radium-226		
106.100	008	EPA 600/4-75-008, p24	Radium-228		
106.100	009	EPA 600/4-75-008, p29	Strontium-89, 90		
106.100	010	EPA 600/4-75-008, p29	Strontium-89		
106.100	011	EPA 600/4-75-008, p29	Strontium-90		
106.100	012	EPA 600/4-75-008, p34	Tritium		
106.100	013	EPA 600/4-75-008, p9	Radioactive Iodine		
106.110	001	EPA 00-01	Gross Alpha		
106.110	002	EPA 00-01	Gross Beta		
106.120	001	EPA 00-02	Gross Alpha		
106.130	001	EPA 00-07	Uranium		
106.140	001	EPA H-02	Tritium		
106.150	002	EPA Ra-03	Radium-226		

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Field of Testing 106: Radiochemistry of Drinking Water

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Sample Preparation
106.160	001	EPA Ra-04	Radium-226		
106.170	001	EPA Ra-05	Radium-228		
106.180	001	EPA Sr-04	Strontium-89, 90		
106.180	002	EPA Sr-04	Strontium-89		
106.180	003	EPA Sr-04	Strontium-90		
106.190	001	EPA (March, 1979), p1	Gross Alpha		
106.190	002	EPA (March, 1979), p1	Gross Beta		
106.190	003	EPA (March, 1979), p19	Radium-226		
106.190	004	EPA (March, 1979), p19	Radium-228		
106.190	005	EPA (March, 1979), p33	Uranium		
106.190	006	EPA (March, 1979), p65	Strontium-89, 90		
106.190	007	EPA (March, 1979), p65	Strontium-89		
106.190	008	EPA (March, 1979), p65	Strontium-90		
106.190	009	EPA (March, 1979), p87	Tritium		
106.190	010	EPA (March, 1979), p92	Radioactive Cesium		
106.190	011	EPA (March, 1979), p92	Radioactive Iodine		
106.190	012	EPA (March, 1979), p92	Gamma Emitters		
106.200	001	DOE Ra-05	Radium-226		
106.210	001	DOE Sr-01	Strontium-89, 90		
106.220	001	DOE Sr-02	Strontium-89, 90		
106.230	001	DOE U-02	Uranium		
106.240	001	DOE U-04	Uranium		
106.250	001	DOE 4.5.2.3	Radioactive Cesium		
106.250	002	DOE 4.5.2.3	Radioactive Iodine		
106.250	003	DOE 4.5.2.3	Gamma Emitters		
106.260	001	SM7110B	Gross Alpha		
106.260	002	SM7110B	Gross Beta		
106.270	001	SM7110C	Gross Alpha		
106.280	001	SM7120	Radioactive Cesium		
106.280	002	SM7120	Radioactive Iodine		
106.280	003	SM7120	Gamma Emitters		
106.290	001	SM7500-Cs B	Radioactive Cesium		
106.300	001	SM7500-3H B	Tritium		
106.310	001	SM7500-I B	Radioactive Iodine		
106.320	001	SM7500-I C	Radioactive Iodine		
106.340	001	SM7500-Ra B	Total Alpha Radium		

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Field of Testing 106: Radiochemistry of Drinking Water

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Sample Preparation
106.340	002	SM7500-Ra B	Radium-226		
106.350	001	SM7500-Ra C	Radium-226		
106.360	001	SM7500-Ra D	Radium-228		
106.370	001	SM7500-Sr B	Strontium-89, 90		
106.370	002	SM7500-Sr B	Strontium-89		
106.370	003	SM7500-Sr B	Strontium-90		
106.380	001	SM7500-U B	Uranium		
106.390	001	SM7500-U C	Uranium		
106.391	001	SM3125	Uranium		
106.400	001	ASTM D2459-72	Radioactive Cesium		
106.410	001	ASTM D2460-90	Total Alpha Radium		
106.410	002	ASTM D2460-90	Radium-226		
106.420	001	ASTM D2907-91	Uranium		
106.430	001	ASTM D3454-91	Radium-226		
106.440	001	ASTM D3649-91	Radioactive Cesium		
106.440	002	ASTM D3649-91	Radioactive Iodine		
106.440	003	ASTM D3649-91	Gamma Emitters		
106.450	001	ASTM D3972-90	Uranium		
106.451	001	ASTM D5673-03	Uranium		
106.460	001	ASTM D4107-91	Tritium		
106.470	001	ASTM D4785-88	Radioactive Iodine		
106.480	001	ASTM D5174-97	Uranium		
106.490	001	USGS R-1110-76	Radioactive Cesium		
106.500	001	USGS R-1111-76	Radioactive Cesium		
106.510	001	USGS R-1120-76	Gross Alpha		
106.510	002	USGS R-1120-76	Gross Beta		
106.520	001	USGS R-1140-76	Radium-226		
106.520	002	USGS R-1140-76	Total Alpha Radium		
106.530	001	USGS R-1141-76	Radium-226		
106.540	001	USGS R-1142-76	Radium-228		
106.550	001	USGS R-1160-76	Strontium-89, 90		
106.550	002	USGS R-1160-76	Strontium-89		
106.550	003	USGS R-1160-76	Strontium-90		
106.560	001	USGS R-1171-76	Tritium		
106.570	001	USGS R-1180-76	Uranium		
106.580	001	USGS R-1181-76	Uranium		

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Field of Testing 106: Radiochemistry of Drinking Water

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Sample Preparation
106.590	001	USGS R-1182-76	Uranium		
106.610	001	SM7500-Rn	Radon-222		
106.620	001	ASTM D5072-92	Radon-222		
106.630	001	EPA 600/2-87/082, p22	Radon-222		

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Field of Testing 112: Radiochemistry of Wastewater

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Sample Preparation
112.010	001	EPA 900.0	Gross Alpha		
112.010	002	EPA 900.0	Gross Beta		
112.020	001	EPA 903.0	Total Alpha Radium		
112.021	001	EPA 903.1	Radium-226		
112.030	001	SM7110B	Gross Alpha		
112.030	002	SM7110B	Gross Beta		
112.040	001	SM7500-Ra B	Total Alpha Radium		
112.050	001	SM7500-Ra C	Radium-226		
112.060	001	ASTM D1890-90	Gross Beta		
112.070	001	ASTM D1943-90	Gross Alpha		
112.080	001	ASTM D2460-90	Total Alpha Radium		
112.090	001	ASTM D3454-91	Radium-226		
112.100	001	USGS 76-177, p.75 & 78	Gross Alpha		
112.100	002	USGS 76-177, p.75 & 78	Gross Beta		
112.100	003	USGS 76-177, p.81	Radium-226		
112.110	001	EPA (1976), p24	Radium-228		
112.110	005	EPA (March, 1979), p19	Radium-228		
112.110	006	EPA (March, 1979), p33	Uranium		
112.110	007	EPA (March, 1979), p65	Strontium		
112.110	008	EPA (March, 1979), p92	Cesium		
112.110	009	EPA (March, 1979), p92	Iodine		
112.120	001	EPA 00-07	Uranium		
112.130	001	EPA 901.0	Cesium		
112.140	001	EPA 901.1	Cesium		
112.140	002	EPA 901.1	Gamma		
112.140	003	EPA 901.1	Iodine		
112.150	001	EPA 902.0	Iodine		
112.160	001	EPA 904.0	Radium-228		
112.170	001	EPA 905.0	Strontium		
112.180	001	EPA 906.0	Tritium		
112.190	001	EPA 908.0	Uranium		
112.210	001	EPA Ra-05	Radium-228		
112.220	001	EPA Sr-04	Strontium		
112.230	001	SM303	Strontium		
112.240	001	SM304	Radium-228		
112.260	001	SM7120	Gamma		

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Field of Testing 112: Radiochemistry of Wastewater

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Sample Preparation
112.260	002	SM7120	Iodine		
112.260	003	SM7120	Cesium		
112.300	001	SM7500-I C	Iodine		
112.350	001	SM7500-U C	Uranium		
112.380	001	ASTM D3649-91	Cesium		
112.380	002	ASTM D3649-91	Gamma		
112.380	003	ASTM D3649-91	Iodine		
112.390	001	ASTM D3972-90	Uranium		
112.400	001	ASTM D4785-88	Iodine		
112.420	001	USGS R-1110-76	Cesium		
112.430	001	USGS R-1111-76	Cesium		
112.440	001	USGS R-1142-76	Radium-228		
112.450	001	USGS R-1160-76	Strontium		
112.460	001	USGS R-1180-76	Uranium		
112.470	001	USGS R-1181-76	Uranium		
112.480	001	USGS R-1182-76	Uranium		
112.490	001	DOE 4.5.2.3	Cesium		
112.490	002	DOE 4.5.2.3	Gamma		
112.490	003	DOE 4.5.2.3	Iodine		
112.500	001	DOE Sr-01	Strontium		
112.510	001	DOE Sr-02	Strontium		
112.520	001	DOE U-02	Uranium		
112.530	001	DOE U-04	Uranium		

Note: Methods cited from SM 300 series are from the 13th edition.

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Field of Testing 118: Radiochemistry of Hazardous Waste

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Enter A for Aqueous Matrix Testing only	Sample Preparation
118.010	001	EPA 9310	Gross Alpha			
118.010	002	EPA 9310	Gross Beta			
118.020	001	EPA 9315	Radium, Total			
118.030	001	EPA 9320	Radium-228			
118.040	001	EPA (March, 1979), p19	Radium-226			
118.040	002	EPA (March, 1979), p19	Radium-228		*	
118.040	003	EPA (March, 1979), p33	Plutonium			
118.040	004	EPA (March, 1979), p33	Uranium			
118.040	005	EPA (March, 1979), p65	Strontium			
118.040	006	EPA (March, 1979), p87	Tritium			
118.050	001	EPA 00-05	Thorium			
118.050	002	EPA 00-05	Uranium			
118.060	001	EPA 00-07	Thorium			
118.060	002	EPA 00-07	Uranium			
118.070	001	EPA (March, 1979), p33	Thorium			
118.090	001	EPA AM-01-1	Americium-241			
118.100	001	EPA H-01	Tritium			
118.110	001	EPA Pu-01	Plutonium			
118.120	001	EPA Ra-01	Radium-226			
118.130	001	EPA Ra-03	Radium-226			
118.140	001	EPA Ra-04	Radium-226			
118.150	001	EPA Ra-05	Radium-228		*	
118.160	001	EPA Sr-01	Strontium			
118.170	001	EPA Sr-04	Strontium			
118.200	001	DOE 4.5.2.3	Gamma			
118.210	001	DOE Am-01	Americium-241			
118.211	001	DOE Am-02	Americium-241			
118.212	001	DOE Am-03	Americium-241			
118.220	001	DOE H-03	Tritium			
118.230	001	DOE Pu-02	Plutonium			
118.231	001	DOE Pu-03	Plutonium			

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Field of Testing 118: Radiochemistry of Hazardous Waste

Lab Name:
Certificate No.:

Subgroup Code	Analyte Code	Method	Analyte	Enter Y for Selection	Enter A for Aqueous Matrix Testing only	Sample Preparation
118.240	001	DOE Pu-10	Plutonium			
118.250	001	DOE Ra-04	Radium-226			
118.260	001	DOE Se-01	Radium-226			
118.260	002	DOE Se-01	Uranium			
118.270	001	DOE Sr-01	Strontium			
118.271	001	DOE Sr-02	Strontium			
118.280	001	DOE Tc-01	Technetium			
118.290	001	DOE U-02	Uranium			

* for use with solid and non-aqueous matrices only

Laboratory Name:

Lab Director or Representative:
(Print Name)

Signature: Date:

Attachment 7
Technical Systems Audit Checklist

Technical Systems Audit Checklist

Project No. _____ **Date of Audit** _____

Project Manager _____ **Auditor** _____

Facility Name _____

Location _____

Weather _____

Field Personnel **FTL:** _____ **SSHO:** _____

Chemist: _____

_____

_____

_____

Description of Field Activities

_____

_____

_____

_____

Summary and Recommendations

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Planning and Preparation

		Yes or No	
1.	Was the field audit announced or unannounced? Comments: _____	☐	☐
2.	Was a QA Project Plan prepared for this activity? Comments: _____	☐	☐
3.	Was a site Health and Safety Plan prepared for this activity? Comments: _____	☐	☐
4.	Were project instructions, work plan, and contractor SOWs distributed to the team? Comments: _____	☐	☐
5.	Were additional instructions given to project field participants (i.e., changes in project plan)? Comments: _____	☐	☐
6.	Was there a written list of sampling locations and descriptions? Comments: _____	☐	☐
7.	Was there a map of sampling locations available to field personnel? Comments: _____	☐	☐

Planning and Preparation (continued)

Yes or No

8. Was equipment list given to equipment coordinator with adequate lead time? ☐ ☐
   Comments: _____

9. Was laboratory given a list of sample containers with adequate lead time? ☐ ☐
   Comments: _____

10. Were analyses scheduled with the laboratory in advance? ☐ ☐
    Comments: _____

11. Was the project team provided with a contact list (names & phone #s)? ☐ ☐
    Comments: _____

12. Are inexperienced or poorly trained staff receiving adequate training and supervision? ☐ ☐
    Comments: _____

13 Was State “One Call” agency contacted prior to drilling, trenching, or excavation to identify buried utilities? ☐ ☐
   If yes, record Ticket No. _____, date of request _____, and renewal date _____
   Comments: _____

14 Was an underground utility location contractor retained to identify buried utilities? ☐ ☐
   Describe means used to track and verify completion of location activities at each sampling station: _____

Planning and Preparation (continued)

		Yes	No
15	Are dig permits required? If yes, record permit number:_____ date of issue _____, and renewal date _____	☐	☐
16	Are hot work permits required? If yes, record permit number _____, date and time of issue _____, and expiration date and time _____	☐	☐

Monitoring Well Installation

		Yes	No
1	Was a daily tail gate safety briefing conducted? If yes, list the items discussed:_____ _____ _____	☐	☐
2	Were the wells located properly with respect to potential contaminant plumes? Comments: _____ _____ _____	☐	☐
3	If field conditions mandated selection of a new location, was the new location properly selected?	☐	☐
	If yes, were the reasons for the relocation properly documented?	☐	☐
4	Were the well locations surveyed?	☐	☐
	Were the exact elevations determined as part of the survey?	☐	☐
	Were elevations referenced to a bench mark?	☐	☐
	Were horizontal coordinates established?	☐	☐
5	Describe the drilling techniques used. _____ _____ _____		
6	Was all in-ground drilling equipment properly decontaminated before initial use and between drilling locations?	☐	☐

Monitoring Well Installation (continued)

Yes or No

7 Describe decontamination procedures (steam cleaner, pressure washer, type of soap used if any, solvent, etc.)

_____

_____

_____

8 How was this equipment stored or otherwise protected after decontamination to prevent recontamination prior to use?

_____

_____

_____

9 What types of casing/screen material were used (black iron, stainless steel, PVC, etc.)?

_____

_____

_____

10 Were well casings/screens properly decontaminated before use? ☐ ☐

Describe decontamination procedure.

_____

_____

_____

11 How was this equipment stored or otherwise protected after decontamination to prevent recontamination prior to use?

_____

_____

_____

12 Were the wells completed to the proper depth? ☐ ☐

Were the wells screened at the proper interval? ☐ ☐

Comments: _____

_____

_____

13 Were the newly installed wells properly secured (sealed) during the overnight grout curing required before installation of protective outer casing? ☐ ☐

Monitoring Well Installation (continued)

		Yes or No	
14	Was a locking cap or some other locking mechanism included as part of the protective outer casing?	☐	☐
15	Describe disposal/storage method used for drilling mud and cuttings.		
16	Were samples of drilling mud, sand pack, gravel, grout, etc., collected for analysis?	☐	☐
	Comments:		
17	Were the wells developed?	☐	☐
	If yes, describe method used		
18	Did the drilling personnel follow required safety protocols?	☐	☐
	Comments:		

Sampling

General Procedures

		Yes or No	
1.	Were sampling locations properly selected?	☐	☐
	Comments:		

General Procedures (continued)

Yes or No

2. Were samples collected starting with the least likely contaminated and proceeding to the most likely contaminated? ☐ ☐
Comments: _____

3. Were new disposable gloves worn during sample collection? ☐ ☐
Comments: _____

4. Was sampling equipment wrapped in aluminum foil or otherwise protected from possible contamination prior to sample collection? ☐ ☐
Comments: _____

5. If equipment was cleaned in the field, were proper procedures used? (This includes storage method for rinse water and solvents.) ☐ ☐
Comments: _____

6. What field instruments were used during this investigation?

7. Were field instruments properly calibrated? ☐ ☐
Comments: _____

8. Were calibration procedures documented in the field notes? ☐ ☐
Comments: _____

General Procedures (continued)

Yes or No

9. Were samples chemically field preserved? ☐ ☐
   Comments: _____
   _____
   _____

10. Were samples iced? ☐ ☐
    Comments: _____
    _____
    _____

11. Were samples of drilling mud, sand pack, gravel, grout, etc., collected for analysis? ☐ ☐
    If yes, please list parameters and procedures.
    _____
    _____
    _____
    _____

Groundwater Sampling

Yes or No

1. Was depth of well determined? ☐ ☐
   Comments: _____
   _____
   _____

2. Was depth to water determined? ☐ ☐
   Comments: _____
   _____

3. Was measuring tape properly decontaminated between wells? ☐ ☐
   Comments: _____
   _____
   _____

4. Were the above depths to water converted to water level elevations common to all wells? Describe how the depths were determined. ☐ ☐
   _____
   _____
   _____

Groundwater Sampling (continued)

Yes or No

5. How was the volume of water originally present in each well determined?
   Comments: _____
   _____
   _____

6. Was the volume determined correctly? ☐ ☐

7. How was completeness of purging determined?
   Volume ☐
   Measure ☐
   Time/Flow Rate ☐
   Cond./pH/T ☐

8. Was a sufficient volume purged? ☐ ☐
   _____
   _____
   _____

9. Describe the disposal of purge water.
   _____
   _____
   _____

10. Was a dedicated (in-place) pump utilized? ☐ ☐
    If no, describe the method of purging (bailer - include type and construction material, pump - include type).
    _____
    _____

11. How were the samples collected?
    Bailer ☐ Passive diffusion bag ☐
    Pump ☐ Peristaltic/Bladder/Centrifugal/Other (check one)
    Other ☐

Groundwater Sampling (continued)

Yes or No

12 Construction material of bailer or tubing:

- S.S. ☐
- Teflon ☐
- PVC ☐
- Other ☐

Design of bailer:

- Open top ☐
- Closed top ☐

Comments: _____

_____

_____

13 If a pump was used, describe how it was cleaned before and/or between wells?

_____

_____

_____

14 Were the samples properly transferred from bailer to sample bottles (i.e., was the purgeable sample agitated, etc.)? ☐ ☐

Comments: _____

_____

_____

15 Was the rope or line allowed to touch the ground? ☐ ☐

16 Was the wetted rope or line discarded after use at each well? ☐ ☐

_____

Surface Water Sampling

Yes or No

1. What procedures were used to collect surface water?

_____

_____

2. Did the samplers wade in the stream during sample collection? ☐ ☐
   If yes, did sampler face upstream while collecting sample? ☐ ☐

Surface Water Sampling (continued)

		Yes or No	
3	Did the sampler insure that disturbed sediments were not collected along with water sample?	☐	☐
4	Note any deficiencies observed during the collection of the surface water samples.		

Soil/Sediment Sampling

1.	What procedures (including equipment) were used to collect the samples?		
2.	Were the samples well mixed prior to placing the sample in the sample container?	☐	☐
3.	Were samples for purgeable organics analysis collected prior to mixing?	☐	☐
4.	Were samples composited? If so, how were composites collected and mixed?	☐	☐
5.	Note any deficiencies observed during the collection of the samples.		

Other Sampling

Yes or No

1. What other types of samples were collected during this investigation?

   _____
   _____
   _____

2. What procedures were used for the collection of these samples?

   _____
   _____
   _____

3. Note any deficiencies observed during the collection of these samples.

   _____
   _____
   _____

Quality Assurance/Quality Control

		Yes or No	
	(While not all of these QA/QC procedures will be necessary during each sampling activity, the following techniques may be employed. If so, please note.)		
1.	Did sampling personnel utilize trip blanks?	☐	☐
2.	Did sampling personnel utilize preservative blanks? If yes, to either of the above questions, list the types and handling of the blanks. _____ _____	☐	☐
3.	Were any equipment blanks collected? If yes, list. _____ _____	☐	☐
4.	Was the water for field blank preparation appropriate for the parameter coverage? Comments: _____ _____	☐	☐
5.	Were any duplicate samples collected? If yes, list the types (parameter coverage, etc.) and describe their handling. _____ _____ _____ _____ _____ _____	☐	☐
6.	Were any spiked samples collected? If yes, list the types (parameter coverage, etc.) and describe their handling. _____	☐	☐
7.	Were the QA/QC samples collected in accordance with the QA Project Plan?	☐	☐
8.	Were staff aware of sample holding times?	☐	☐

Field Documentation and Chain-of-Custody

		Yes	No
1.	Were Sample I.D. Tags filled out completely (i.e., station no., location, date, time, analyses, signatures of samplers, type of preservative)? Comments: _____	☐	☐
2.	Were Chain-of-Custody Records completed for all samples? Comments: _____	☐	☐
3.	Did information on Sample I.D. Tags and Chain-of-Custody Records match? Comments: _____	☐	☐
4.	Were samples shipped to the laboratory? If yes, did the Chain-of-Custody Record indicate the method of sample shipment?	☐	☐
5	Was a Chain-of-Custody Record included with the samples in the shipping container?	☐	☐
6	Were samples properly secured to maintain custody after collection? Comments: _____	☐	☐

Field Documentation and Chain-of-Custody (continued)

Yes or No

7 Were sample tags, Chain-of-Custody forms, and field notebook signed by sampling personnel? ☐ ☐
Comments: _____

8 Does the field notebook contain adequate information about each sample including the sample I.D. number, date, location, and information necessary to reconstruct the sample? ☐ ☐
Comments: _____

9 Were entries to the field notebook made in ink? ☐ ☐
Comments: _____

10 Were corrections properly executed with one line through the error in the field notebook? ☐ ☐
Comments: _____

11 Was sampling documented with photographs? ☐ ☐
If yes, was a photolog maintained?

12 Were amendments to the project plan documented (on the project plan itself, in a project logbook, elsewhere)? ☐ ☐
Comments: _____

Debriefing Following Field Audit

		Yes	No
1.	Was a debriefing held with project participants after the audit was completed? Comments: _____	☐	☐
2.	Were any recommendations made to project participants during the debriefing? If yes, briefly describe recommendations made.	☐	☐